Digital Transformation and Agency in Construction Companies’ Journey Toward Sustainability

A study of the Swedish construction industry
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Abstract

Background: Digital transformation is an important step in businesses’ quest for environmental sustainability, that changes their business models to create, deliver, and capture value from the use of digital technologies. Another field of research that concerns transformations, is research on socio-technical systems. It explains the adoption of new technologies, by incorporating the social context in which transitions happen. An industry that has been notoriously blamed for being conservative and having sustainability concerns, is the construction industry.

Purpose: The purpose of this study was to contribute to socio-technical systems theory, by investigating how interactions in the socio-technical regime can help digitally transform established construction companies and make them more environmentally sustainable.

Method: A qualitative case study was performed around Smart Built Environment, a strategic innovation program. From the program, nine reports were examined, and four employees were interviewed. Furthermore, three interviews were conducted with employees of three large construction companies, which were part of Smart Built Environment’s projects. The reports and interviews were used to develop a theoretical framework, which was constructed from existing literature on socio-technical systems, business models, and digital transformation.

Conclusion: The results show that culture and habits, and policy and regulations in the regimes have the greatest influence on the digital transformation of construction companies. This is because they influence the relationships between the construction companies and other actors in the construction value chain. Changes to business models that were identified to facilitate the digital transformation were long-term collaborations, product-based development, co-creation, and using digital technologies as a use case for sustainability.
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1. Introduction

In this chapter, the background to the study is presented. Followed by a problem statement that highlights gaps in the current research, expresses how our research intends to close that gap, and what the scope of our research is. The chapter concludes with the purpose of the research, and the research questions.

1.1 Background

The Sustainable Development Goals (SDGs), part of the 2030 Agenda for Sustainable Development and agreed upon by the United Nations in 2015, emphasize the role of digital technology in sustainable development (Camodeca & Almici, 2021). Previous research confirms that digital transformation plays a major role in contributing to the SDGs (Bican & Brem, 2020; Camodeca & Almici, 2021).

Digital transformation is described as how companies transform their business models through the integration of digital technologies (Bican & Brem, 2020). This has the potential to change the socio-technical environment in which the business is embedded, as the transformation entails changing the interactions with partners, customers, and suppliers (Bican & Brem, 2020; Ufua et al., 2021). Without a transformation of existing businesses, the economic and environmental challenges of the future cannot be solved sustainably (Bican & Brem, 2020).

A business model describes the fundamentals of how a company creates, delivers, and captures value (Osterwalder et al., 2010). It identifies the company's value proposition, the network associated with the business, the cost and revenue sources, and other key fundamentals, that together determine the way the company “does business” (Bican & Brem, 2020). A business model is digital when digital technologies cause essential changes in the way business is carried out and revenue is generated (Bican & Brem, 2020).
1.2 Research Problem

Despite increasing interest in both, digital transformation and Agenda 2030’s sustainable development goals, numerous unexploited aspects remain (Castro et al., 2021). Existing studies focus on the relationship between digital transformation and environmental sustainability, showing a positive relationship (Balasubramanian et al., 2021; Belhadi et al., 2021; Camodeca & Almici, 2021; Castro et al., 2021; Denicolai et al., 2021; Ghobakhloo, 2020; Khan et al., 2021; Ufua et al., 2021). Belhadi et al. (2021) proved that circular business models mediate the relationship between digitalization and environmental sustainability in a positive way.

However, what these studies do not show is how existing business models are affected by digital transformations. Furthermore, literature about socio-technical transitions focuses too much on the inertia of regimes (Geels, 2011). More recent research identified the agency of actors within these regimes (Bolton & Hannon, 2016; Geels, 2014; Ludeke-Freund, 2020). As climate change is becoming more urgent, insights into how the agency of businesses can contribute to the transformation of socio-technical regimes to be environmentally friendly –yet profitable– could help solve the climate problem.

An industry where digital transformation could play a major role in contributing to the SDGs is the construction industry. It has several sustainability concerns, with high carbon emissions, increasing costs, and health and safety risks (Balasubramanian et al., 2021). Action needs to be taken in the industry to address these. It is expected that more than two-thirds of the world population will live in urban areas by 2050 and the construction industry plays a critical role in contributing to the sustainable development of cities and countries (Balasubramanian et al., 2021).

Nevertheless, the construction industry is seen as one of the most conservative industries and has traditionally been associated with a low degree of technological solutions, corruption, and poor quality (Balasubramanian et al., 2021; ECSO, 2021). The digital transformation has been slow in the sector, but in the last decades, significant developments have been made (Cetin et al., 2021; ECSO, 2021). How businesses and regimes transition depends on the socio-technical environment (Bican & Brem, 2020). Therefore, the scope of this study is limited to the Swedish construction industry.
1.3 Research Questions

With this study, we want to contribute to socio-technical systems theory by investigating how interactions in the socio-technical regime can help transform established construction companies and make them more environmentally sustainable. Furthermore, the results could be used by managers and governments as a roadmap for the construction industry toward sustainability.

This will be done by answering the following research questions (RQs).

*RQ1:* What interactions in the socio-technical regime can influence construction companies to transform their business models using digital technologies?

*RQ2:* What changes to business models of construction companies need to happen to facilitate a digital transformation driven by environmental sustainability?
2. Literature Review

This chapter aims to provide the theoretical background related to the topic of digital transformation of business models. Three main areas are introduced, socio-technical transitions, business models, and digital transformation. After that, a synthesis of the main areas is made to highlight gaps in the research. The chapter ends with an introduction to the theoretical framework, which is used as a tool in conducting the study.

In this chapter, a critical review is performed of literature on socio-technical transitions, business models (and their connection to sustainability), and digital transformation of businesses and the influence of this phenomenon on the sustainability of businesses.

2.1 Web of Science

As described above, the literature review comprises three parts. To identify relevant literature in these three research fields, three different searches were performed in the Web of Science database. After searching with different keywords and filters, we decided on which searches should use for this review.

The articles on socio-technical transitions were found by searching for the following keywords, in the abstracts: (“socio-technical *” OR “sociotechnical *” OR “socio technical *”) AND “business model”. We searched for articles regarding business models by using the keywords, in the author keywords: “business model” AND “digital*” AND “sustain*”. Our final search –on articles about digital transformation– consisted of the keywords: (“industry 4.0” OR “digital” OR “digital transformation” OR “digitalization”) AND (“environment* sustain*” OR “sustain*” OR “sustainable development goals” OR “SDG”). These keywords were searched for in the title of articles.

The first searches on the respective research topics resulted in 71, 43, and 808 results. After that, the first and third searches were filtered on the categories “Management” and “Business”. The second search was filtered on the categories “Management”, “Business”, and “Environmental Studies”. This was done to ensure only relevant literature was
included. Furthermore, we only included articles from journals with an impact factor above one to ensure the use of articles from high-quality journals.

This resulted in 14 articles related to socio-technical transitions, of which 4 were included in the review. Also, 3 seminal works were identified outside of the search. These were also included. For articles about business models, the search gave 32 results. Of these 32, 8 were useful for the literature study. 7 seminal works were identified outside of the search and selected for inclusion. The final search –on articles about digital transformation– resulted in 53 articles, of which 7 were selected for inclusion in the review.

2.2 Socio-Technical Transitions

Research on socio-technical transitions is concerned with how the introduction of radical new technologies happens and how it affects the wider social system. For a new technology to be widely used, the development of new technologies should go hand in hand with embedding it in its broader societal context (Schot & Geels, 2008). Extant literature explains the phenomenon of socio-technical transitions as technological transitions that change the way societal functions are executed, consisting of interactions on different levels of the socio-technical hierarchy (Geels, 2002; Kemp et al., 1998; Schot & Geels, 2008).

Early studies in socio-technical transitions focused on strategic niche management (SNM), as a method for further developing and introducing new technologies (Kemp et al., 1998; Schot & Geels, 2008). Later, it became clear that the bottom-up approach and focus of SNM on the technological side was too narrow to explain a wider adoption of technologies (Schot & Geels, 2008). The multi-level perspective (MLP) of Geels (2002) provided a better explanation, by incorporating the need for adaptation and co-evolution of the niches with what is happening in the regimes and landscape (Geels, 2002; Schot & Geels, 2008).

The MLP identifies three different hierarchical levels: socio-technical niches, socio-technical regimes, and the socio-technical landscape. An alignment of changes within the
respective levels of the hierarchy can cause regime changes, which facilitates the wider adoption of a technology (Geels, 2002; Kemp et al., 1998; Schot & Geels, 2008). At the top of the socio-technical hierarchy, we find the landscape. The landscape consists of heterogeneous technology-external factors that are hard to influence e.g., climate change, and macro-political decisions (Geels, 2002). In the middle of the hierarchy, the socio-technical regimes can be found. A socio-technical regime consists of a set of rules that are adhered to by social groups that act within that specific regime (Geels, 2002; Schot & Geels, 2008). These actors or social groups define the technical trajectories that are followed and cause stability within the socio-technical hierarchy. A multitude of these regimes exists, all characterized by their own set of rules. The interconnected nature of the regimes causes innovations, that rise up from them, to be of an incremental kind (Geels, 2002). Also, it is this interconnectedness that makes regimes stable. However, the strict rules and regulations within the regime can also cause tensions (Geels, 2011). At the bottom of the socio-technical hierarchy, we find socio-technical niches. They are spaces wherein radical innovations can develop, protected from the forces that are present in the socio-technical regimes (Geels, 2002).

The idea behind the socio-technical hierarchy is that radical innovations are developed in niches and that the wider adoption of these innovations can be caused by regime shifts. These shifts occur because of ongoing processes at the socio-technical landscape and regime levels (Geels, 2002; Kemp et al., 1998). In the literature, the regimes are seen as inert, and the successful management of niches is deemed necessary to cause regime shifts (Kemp et al., 1998; Schot & Geels, 2008). However, the context in which these shifts happen plays an important role and attention should be paid to other change models –than the bottom-up change model– as well (Geels, 2011; Schot & Geels, 2008). Furthermore, the view of regimes being inert has been criticized. Previous research is said to not pay enough attention to the agency of different actors within the regime (Geels, 2011).

2.2.1 The Role of Agency

More recently, two separate views on innovation are being combined: business model innovation and socio-technical transitions. This can bring more clarity to the role agency plays within the socio-technical transition process (Bolton & Hannon, 2016; Ludeke-
Freund, 2020). The “activity system” approach of Bolton and Hannon (2016) compares business models and socio-technical systems to get a better overview of business model innovation and socio-technical change as complementary views, rather than creating a framework. They note that business models show the role of agency and actors in the market better, while socio-technical systems explain the broader context in which these actors are embedded. Furthermore, it is argued that the relationship between business models and sustainability transitions is constituted by an alignment of the business model with the changing socio-technical system. Geels (2014) adds to his work –the MLP– by elaborating on the role policy plays in socio-technical regimes. He indicates that politicians can cause a regime to destabilize by enforcing policies. However, there exists no one-way relationship between other actors within the regimes and politicians. Politicians can also be influenced by the incumbent firms. The existence of alliances can make the regime even more resistant to change. Emphasizing the importance of understanding how regimes are destabilized by the interactions within the regime and the importance of the role of agency. Ludeke-Freund (2020) goes deeper into the dynamics of the agency –which Bolton and Hannon (2016) and Geels (2014) already discussed– by drawing from previous research. Sustainable entrepreneurs are seen as agents who align their (existing) business models with innovations. These agents are embedded in the socio-technical system that they influence, but also get affected by. This results in a framework, in which business models mediate the relationship between sustainability innovation and a business’ economical and sustainability performance. Furthermore, private financing and public policy moderate this relationship.

2.3 Business Models

2.3.1 What is a Business Model?

According to Teece (2010), the essence of a business model is to describe the way a company delivers value to customers, makes customers pay for that value, and converts those payments to profits. Thus, the architecture of a business model includes making hypotheses on what customers need, how the business should be organized to meet those needs, and making a profit by doing that. An organized way of putting different hypotheses together on how to structure a business has been developed by Osterwalder et al. (2010), with the Business Model Canvas. It is the most comprehensive template
describing a business model and comprises nine parts: value proposition, key activities, key partners, key resources, customer segments, customer relationships, channels, cost structure, and revenue streams. Together, they describe the value a company offers to segments of customers, the architecture of the company, and its network of partners that create, market, and deliver the value to generate profitable and sustainable revenue streams (Osterwalder et al., 2010; Osterwalder et al., 2005). Acciarini et al. (2021) emphasize that the business model highlights the way a company delivers value to its end-user and can be seen as a basis for the explanation of structure in the value chain. A value chain refers to all activities that generate and add value to the end-user in all steps during the process, for instance from the extraction of raw materials to delivery to the final consumer.

2.3.2 The Transition of Business Models
Using the business model should be seen as an iterative process for a company. Teece (2010) argues that business models must transform over time, as technologies, markets, and legal structures change. New technology has emerged over the last decades and has given companies different opportunities to meet customers’ needs and therefore re-evaluate their value propositions. In addition to adopting business models to facilitate and manage technological changes, companies can view the business model as a subject of innovation (Zott et al., 2011). Business model innovation involves a change in how companies create, deliver, and capture value through business development, and there is an increasing consensus that a business model is important for a company’s performance (Zott et al., 2011). Kim (2021) argues that business model innovation is essential to survive in a competitive market and Johnson et al. (2008) reason that maintaining a successful business is realizing when it needs a fundamental change. Chesbrough (2010) explores the barriers to business model innovation. Some of the findings show that organizational processes must change, that companies must adopt an efficient approach toward business model experimentation, and that organizations need to find internal leaders to drive the changes. At the same time, the whole organization must embrace the new model, while maintaining the value of the current business model.
Digitalization and sustainability are the two main trends that affect business models (Acciarini et al., 2021; Li et al., 2020). Numerous scholars state that new technologies themselves have no value for companies. The economic value originates when the technology can be commercialized by a business model and managers expand their perspective to find a business model that captures the value of the technology (Chesbrough, 2010). To be able to unlock the value embedded in new technologies and convert it to market outcomes is an important role of the business model for a company (Zott et al., 2011). This leads to the argument that digital technologies are a powerful force, that is pushing companies to innovate and embrace new business models (Kim, 2021).

A new business model that has emerged in recent literature is the circular business model. Described by Ranta et al. (2021) as a holistic view of a firm's business, including a value proposition that attracts customers to choose a company over its competitors, supports value creation, delivers a system that fulfills the value proposition, and uses value capture mechanisms that allow the company to capture part of the value that is created as profit. While adhering to principles of a circular economy. The circular business model is derived from the transition to a circular economy, which aims to minimize resource inputs and waste emissions through circular activities of reducing, reusing, recycling, recovering, and remanufacturing (Huynh, 2021).

Digital technologies are considered essential enablers and triggers for circular business models in various industries (Huynh, 2021; Ranta et al., 2021). No circular business model can be adapted to all sectors, different sectors require different business models, and different business models require different digital technologies (Huynh, 2021). Cetin et al. (2021) argue that there urgently needs to be a paradigm shift from a linear to a circular business model in the construction industry to address the emissions, resource diminution, and waste caused by the industry.

2.3.3 Business Models and Sustainability
One key challenge in designing business models is to enable social and environmental benefits to be translated to economic value for companies. Bocken et al. (2014) state that
it is unclear how businesses capture economic value from sustainability. Gregori and Holzmann (2020) found that if those challenges cannot be solved in the business model, it can lead to unstable business and delay social and environmental value creation. Furthermore, Bican and Brem (2020) argue that without the transformation of businesses the economic and environmental challenges of the future cannot be solved sustainably. Gregori and Holzmann (2020) state that digital technologies can be supportive in solving the challenges of capturing value from sustainable solutions, that statement is built on the assumption that the transformative capacity of digitalization changes the approach to sustainability issues.

2.4 Digital Transformation

2.4.1 Digitization, Digitalization, and Digital Transformation – Definitions

Digitization, digitalization, and digital transformation are closely related terms that are all used to describe the phenomenon of transitioning to digital technologies in a business context. The differences are subtle but entail the size of transition that takes place within the business. Digitization is the transformation of physical data into digital data (Bican & Brem, 2020). Digitalization goes further, by using digitization techniques to transform business processes. Instead of just digitizing the business processes, they are transformed to create a digital business environment. In this regard, digitization is applied as a socio-technical process (Bican & Brem, 2020). Digital transformation does not only transform business processes, but also the business model. As business models entail interactions with partners, customers, and suppliers, this has the potential to impact the broader socio-technical environment (Bican & Brem, 2020).

Other constructs of digital transformation can be found in existing literature, depending on the context in which the concept is used (Ufua et al., 2021). However, regarding the scope of our study and the interactive properties of digital transformation with the businesses’ socio-technical environment in the definition above, only literature that covers how businesses are transformed by using digital technologies and the effects on environmental sustainability was included in this literature review.
2.4.2 Dynamics of Digital Transformation

Existing literature on digital transformations is mostly scattered into distinctly defined concepts. However, to get a common understanding of how digital technologies are applied to sustainability it is important to understand the relationship between these concepts and how they come to be (Bican & Brem, 2020). Concerning this study, we look at how digital transformation of businesses happens and how it is executed to have a positive effect on environmental sustainability.

Bican and Brem (2020) constructed a framework to explain the digital transformation of incumbents. They identified that digital transformation constitutes the use of a digital business model and the technological know-how to employ digital technologies, which affect the continued discovery of technologies (innovation) within the business. Also, digital readiness is seen as an enabler for innovation directly and indirectly through the facilitation of technological know-how. External collaborations support the adoption of technology, hence increasing digital readiness. Furthermore, aligning activities –other than digital activities– with the individual business model of the firm is necessary to get desired effects of the digital transformation e.g., sustainability.

The most studied concept in this stream of literature is Industry 4.0, which is the digital transformation of manufacturing firms’ business models (Khan et al., 2021). In this regard, Khan et al. (2021) found that the integration of blockchain technology positively impacts circular economy practices, while circular economy practices also have a positive effect on the firms’ economic and environmental performance. Belhadi et al. (2021) concluded that the operating capabilities for industry 4.0 positively affect the digital transformation of the business and the organizational ambidexterity of the business. Furthermore, the digital business transformation was found to have a positive effect on organizational ambidexterity. Digital business transformation and organizational ambidexterity both had a positive impact on the environmental sustainability of the supply chain. This relationship was found to be moderated by having a circular business model. Paiola et al. (2021) studied the effects of digital servitization on business models in the manufacturing industry and the impact of transformed business models on sustainability. Digital servitization is the gradual transformation of a firm’s value proposition from the sale of products to services, using digital technologies. The revenue streams can also be
affected, from sales to product fees for example. Furthermore, their cost structures, activities, and relationships with partners change. The latter is indicated as the transformation of networks, in which businesses’ ecosystems should be orchestrated to facilitate co-creation between partners. They found that it is necessary to align digital servitization and network transformation activities to have a positive effect on the sustainability of firms. Ciliberto et al. (2021) also indicated that supply chain firms adopt circular economy practices, by changing activities from only producing to maintenance, repair, reuse, remanufacturing, refurbishing, and recycling. Digital technologies were found to provide the firm with the necessary capabilities to implement the reverse logistics that make this possible. In the same context, Patyal et al. (2021) go even further by proposing that also the waste of materials and energy is reduced.

2.5 Synthesis and Research Gap

Early research on socio-technical transitions argued that transitions from one regime to another should come from radical innovations, developed in niches (Geels, 2002; Geels, 2011; Kemp et al., 1998; Schot & Geels, 2008). However, more recent studies indicate that the agency of actors within the socio-technical regimes is neglected in the story about socio-technical transitions (Bolton & Hannon, 2016; Geels, 2011; Ludeke-Freund, 2020). They argue that regime actors play a role in this transition and that the innovations within the regimes can help the regimes to transition (Bolton & Hannon, 2016; Ludeke-Freund, 2020). More specifically, business models are investigated in this aspect.

The literature on digital transformation is concerned with the effects of using digital technology on businesses and the environment. Studies are promising, as digital transformation has proven to help businesses in becoming more sustainable (Belhadi et al., 2021; Ciliberto et al., 2021; Khan et al., 2021; Paiola et al., 2021; Patyal et al., 2021). Furthermore, digital transformation transforms the business models of companies. Business models identify the company’s value proposition, the network associated with the business, and the cost and revenue sources (Bican & Brem, 2020). In this regard, we argue that the business models of firms could be seen as a reflection of agency within the socio-technical regime.
The extant literature on socio-technical transitions, digital transformations, and business models provides us with a framework to investigate how interactions in the socio-technical regime can help digitally transform established construction companies and make them more environmentally sustainable. Most research on the transition of firms to a digital business model focuses on the manufacturing industry. An industry that is regarded as conservative and that has been studied less, is the construction industry. Also, how businesses and regimes transition depends greatly on their socio-technical environment (Bican & Brem, 2020; Khan et al., 2021). We chose to limit the scope of our study to the Swedish construction industry.

2.6 Framework

The theoretical framework for this study consists of two parts. The first part (Figure 1) is used to analyze the interactions in the socio-technical system, while the second part (Figure 2) is used to analyze the necessary changes to business models. These frameworks will later be updated in three rounds during the analysis.

*Figure 1 – Framework for analysis of interactions in the socio-technical system. Developed from existing literature, based on Bican and Brem (2020), Geels (2002), Geels (2014), Ludeke-Freund (2020), and Paiola et al. (2021).*
Figure 1 represents part of the framework that was constructed from existing literature. From the MLP by Geels (2002) we focus on the socio-technical landscape and socio-technical regime, as the dynamics of agency are shown in these parts (Geels, 2011). We propose a dyadic relationship between the global climate and the socio-technical regime, in which global climate change puts pressure on the regime, and the regime has the potential to influence the global climate. The regime contains the construction companies’ business model mediation space. According to Ludeke-Freund (2020), this mediation space makes firms adopt digital business models and become more sustainable. The relationship between digital technologies, business models of firms, and environmental sustainability is moderated by public policy and private financing. Geels (2014) proposed that policymakers also get affected by incumbents. Furthermore, technological knowledge, societal stakeholders, financial stakeholders, and networks of industry actors are considered to influence the digital transformation of firms (Bican & Brem, 2020; Ludeke-Freund, 2020; Paiola et al., 2021). All of these, except technological knowledge, are expected to get influenced by the digital transformation of firms as well.

Figure 2 gives a more detailed view of the business model mediation space of Ludeke-Freund (2020). This part of the framework will be used to analyze the changes in business models that are needed to facilitate digital transformation. The Business Model Canvas...

![Figure 2 - Framework for analysis of changes to the business model. Developed from existing literature, based on Ludeke-Freund (2020), and Osterwalder et al. (2010). This framework gives a more detailed view of the business model mediation space.](image-url)
by Osterwalder et al. (2010) is used for this, as it provides us with the most comprehensive view of a business model.
3. Methodology & Method

This chapter describes how the research was conducted. Initially presenting the research philosophy, approach, and design. Later, the processes of data collection and data analysis are explained. Finally, how quality is assured and the ethical implications of the study are presented.

3.1 Research Philosophy

Research philosophy lies at the core of research design. The chosen research philosophy will have implications for the methodology, methods, and techniques that are used. This means that taking a philosophical stance in research is about making sure that the research design is sound. Research philosophy comprises two different parts: ontology and epistemology (Easterby-Smith et al., 2021).

Ontologies provide us with views about the nature of reality and existence (Easterby-Smith et al., 2021). With our research, we take the stance of internal realist ontology, which states that truth exists independently of the observer and that it is only possible to indirectly observe this truth (Easterby-Smith et al., 2021). We believe that agency within socio-technical regimes exists –along other transition paths. Also, we believe that different types of existing research can help us in obtaining a more holistic view of this phenomenon. In this regard, we believe agency in the construction industry can be explained by looking at the business models of firms and –more specifically– the digital transformation of business models.

Epistemologies are assumptions made about how the nature of the world can be analyzed (Easterby-Smith et al., 2021). With our research, we try to increase the understanding of agency by incumbents in the construction industry, rather than explaining causal relationships. This is consistent with a social constructionism epistemology. Social constructionism is the assumption that reality is determined by people, which means it is most important to appreciate the way people make sense of their experiences (Easterby-Smith et al., 2021). Geels (2011) also indicated that the MLP is meant to be used as a heuristic device that helps to explain sequences of events, instead of proving causality.
3.2 Research Approach

The research approach is abductive, as we built a theoretical framework from existing literature and developed the framework by using the data that was collected in this study. The guidelines for systematic combing were used, as described by Dubois and Gadde (2002). Systematic combining is a research approach, in which the researcher goes back and forth between a preliminary framework and empirical data. The benefit of this approach is that—over time—the researcher gets a better understanding of the theory and the empirical data. Dubois and Gadde (2002) argue that this approach provides a continuous confrontation between theory and the empirical world, orchestrated by the continuous confrontation of the developing framework with the developing case.

Systematic combining consists of two processes: matching, and direction and redirection. By alternating between the framework, data sources, and analysis, theory is matched with reality. However, this does not mean that data should be forced to fit existing theory. An important part of matching is direction and redirection of the study. Direction happens in case data is found in line with the current framework, while redirection takes place when the data found is not in line with the current framework. Redirection of the study through triangulating different types of data allows the researcher to discover new depths of the research problem—achieving the ultimate goal of systematic combining—the development of theory (Dubois & Gadde, 2002).

3.3 Research Design

Research on the topic of digital transformation of business models is scarce, therefore we decided our research to be qualitative. Since qualitative research involves studying subjects in their natural setting and attempting to make sense of these subjects in terms of the meanings that the participants bring to them (Creswell, 2013). One contribution of qualitative research is to understand how and why context matters (Patton, 2015), in our research the context is the socio-technical regime and how it influences the business model of construction companies. Qualitative studies focus on understanding human experience (Silverman, 2013), and using a qualitative method enables an in-depth analysis of opportunities and barriers that actors within the construction industry are facing in transforming their business models to be more sustainable. Hence, the proposed
qualitative research design is considered suitable for answering the intended research questions. Within qualitative research, different strategies can be used depending on the purpose of the study. We decided on an instrumental case study design. A case study because it enables a rich understanding of the context, and instrumental because we want to understand a more general phenomenon and the case is examined primarily to provide insight. The case is looked at in-depth but our focus is on something else, the digital transformation of business models (Silverman, 2013).

The case selected is Smart Built Environment, a program that outlines how the built environment sector can contribute to Sweden’s journey toward being at the forefront of digitalization on a global level and achieving intelligent and sustainable cities (Andersson & Lázaro Morales, 2020). Smart Built Environment is introduced more in-depth in section 4.1. The unit of analysis of the case study is different actors within the program, divided into two different sub-units of analysis, the internal and external actors of Smart Built Environment. The internal actors consist of individuals employed by Smart Built Environment, to either manage the program or do research within the program. The external actors consist of individuals employed at large construction companies that are involved in Smart Built Environment’s projects. Smart Built Environment works together with a lot of organizations in the Swedish construction industry and researches how businesses are transformed. Therefore, they could provide us with useful insights and contact information from different construction companies. The choice was made to study large construction companies, as they have the resources to work with digital technologies. Sampling was done purposive, as the case illustrated features and processes which were interesting to answer the research questions (Silverman, 2013).

3.4 Data Collection

Our research is based on two sources of empirical data, primary data comprising interviews with actors within Smart Built Environment, and secondary data consisting of reports published by Smart Built Environment. Triangulation of the data collected from the two different sources is used to provide an in-depth understanding (Easterby-Smith et al., 2021).
3.4.1 Primary Data

The primary data was collected through seven semi-structured interviews with different actors, internal or external to Smart Built Environment. Primary data allows for collecting data that is relevant and specific to the case and refers to information collected by researchers, from different respondents to gain new insight and understanding of the subject that are being investigated. Primary data also has the advantage that its design and content can be controlled by the researchers, hence ensuring the quality of the data (Easterby-Smith et al., 2021). The exploratory nature of our research makes the use of semi-structured interviews with open-ended questions suitable as the main source of empirical data since it allows the respondents to speak freely (Patton, 2015). The respondents were contacted using snowball sampling, as relevant persons within Smart Built Environment were first identified, later they were asked for contact information from other suitable persons within the program (Easterby-Smith et al., 2021).

The interview questions were prepared in advance, but the nature of semi-structured interviews allowed for follow-up questions and a certain flexibility. Questions were created in line with our research purpose, findings from the literature review, and findings from the analysis of the reports. The questions in the interview guide were divided into three categories: socio-technical regime and landscape, business models, and how digital technologies are part of the climate solution. Key questions in each category can be found in the interview guide in Appendix A. All interviews were conducted in English, with the possibility for the participants to use Swedish words –if needed– to explain matters specific to the Swedish construction industry.

3.4.2 Secondary Data

The secondary data was collected through different reports from Smart Built Environment. Smart Built Environment supports and coordinates different strategic projects that research digitalization in the industry. From the finished projects –with published reports within the focus area value chains and business models– the most relevant reports were chosen, landing on a total of nine reports. The reports were retrieved from Smart Built Environment’s website, a list of the analyzed reports can be found in Appendix B. The reports were originally written in Swedish but translated to English
using Google Translate. This was done to enable both researchers to use the same language in the analysis of the reports, making the analysis more cohesive.

In this study, the secondary data was used to take advantage of and build on existing research, and together with the primary data build a more complete picture of digitalization in the Swedish construction industry (Easterby-Smith et al., 2021).

3.5 Data Analysis

For a long time, grounded theory has served as the dominant type of analysis for developing theory (Timmermans & Tavory, 2012). According to Timmermans and Tavory (2012), this inductive approach to analysis has been criticized for the fact that preexisting theories should be neglected, however, the researcher should still possess theoretical sensitivity toward existing theories. This causes ambiguity and raises the question if the development of theory needs preexisting theory. In this regard, an abductive approach toward grounded theory methods was introduced (Timmermans & Tavory, 2012). In this abductive approach, preexisting theory plays a major role, as it is used as a plausible explanation for empirical data or can be built upon by the empirical data. It is argued that the methodological guidelines of grounded theory –such as revisiting phenomena, defamiliarization, and alternative casing– can enhance abductive analysis (Timmermans & Tavory, 2012).

The present study takes an abductive approach toward grounded analysis. The analysis was based on the description of Easterby-Smith et al. (2021) for grounded analysis. Also, the guidelines of Timmermans and Tavory (2012) were applied to facilitate an abductive analysis. The steps that were taken are coding, conceptualization, linking, updating the existing frameworks, and re-evaluation. Coding is the codification of pieces of texts in the transcribed interviews and reports, based on their content. In conceptualization, the codes were categorized based on the developed frameworks –if this was possible. If categorizing through the frameworks was not possible, they were categorized to highlight the anomalies in the data. Later we would look for patterns in these uncategorized pieces of data, develop new categories, and categorize them accordingly. Using the categories and codes, concepts were identified for each category. From the concepts, links were
identified to show relationships between different categories. Again, this was either done based on the available data in the frameworks or based on the information available in the data. Next, the existing frameworks were updated with our findings. The last step – re-evaluation – was done by executing three rounds of analysis. First, the reports from Smart Built Environment were analyzed. After that, interviews were analyzed in two rounds, based on the sub-unit of analysis –internal and external to Smart Built Environment. Furthermore, data collection and analysis were done in parallel to test our preliminary findings during interviews.

It is important to note that transcribing the interview data facilitates revisiting (Timmermans & Tavory, 2012). By coding and taking notes during the analysis, defamiliarization of the data occurs. This helps to reason about the data in ways that could be overlooked when only looking at the transcriptions and reports (Timmermans & Tavory, 2012). Furthermore, alternative casing is provided by finding possible explanations from the theoretical frameworks – that were constructed earlier – and expanding them. It is the nature of the frameworks, which are grounded in extant literature, that promote a rigorous analysis of the empirical data (Timmermans & Tavory, 2012). The data analysis was conducted iteratively – in combination with data collection – as suggested by Dubois and Gadde (2002).

3.6 Quality Assurance

Easterby-Smith et al. (2021) argue that the quality of a qualitative study depends on the researchers’ approach to the study. By conducting research in a reflexive and transparent way, the researchers can assure the quality of the research. To ensure that our research is reliable and trustworthy, we will elaborate on the four criteria that Guba (1981) presented to determine the trustworthiness of research: credibility, transferability, dependability, and confirmability.

3.6.1 Credibility

Credibility refers to the truthfulness of the data that researchers capture and interpret in their studies, concerning the participants and the context in which the study happens (Guba, 1981). One way of assuring credibility is through triangulation, which refers to
the use of different data collection sources and techniques to provide different viewpoints (Guba, 1981). In this study, triangulation was used to ensure credibility, by verifying the truthfulness of different sources. Interviews were conducted –with different actors internal and external to Smart Built Environment– and reports were analyzed to create a holistic view. Triangulation makes sure that a conclusion can be made with certainty when different data points at the same thing (Guba, 1981). Furthermore, during the interviews we shared findings with participants, asking questions related to findings from the reports and other interviews. Testing data with members of the relevant source group is called member checking and makes sure that collected data and interpretations made by the researchers are truthful (Guba, 1981). In the early stages, the purpose of the study was discussed with researchers in the field, to revise certain aspects of the study. Analyzing different types of data and perspectives in different rounds and aggregating them, makes sure that different perspectives are taken into account during the analysis. This adds to the structural coherence of the work (Guba, 1981). To further ensure credibility, all interviews were recorded, so the data could be reevaluated throughout the entire analysis process.

3.6.2 Transferability
Transferability refers to the degree to which research findings can be applied to other contexts (Guba, 1981). The purposive sampling for the selection of the case had the intention to maximize the amount of information that could be uncovered, rather than finding a representative sample. The case of Smart Built Environment maximized the available information through their previously conducted research and the rich knowledge of the people we interviewed. This made it possible to produce context-relevant findings, that increase transferability (Guba, 1981). Furthermore, the frameworks that were developed throughout the study give a clear description of the context in which the study took place. This way, readers can assess the degree to which the findings apply to other contexts (Guba, 1981). Information and decision regarding the design, approach, and philosophy have been explained systematically and in detail to allow transferability to other cases (Guba, 1981).
3.6.3  Dependability
Dependability is to which level findings could be reproduced by replicating the research, assuming comparable respondents and context (Guba, 1981). To enhance the dependability of this study an interview guide, analysis process, and the sampling strategy have been provided to make the research process traceable.

3.6.4  Confirmability
Confirmability refers to the degree to which findings are only a function of the participants and the research’s context. The aim of showing confirmability is to minimize biases from researchers. A confirmable study should not be based on the researchers’ preferences and maintain a neutral stance to avoid personal bias (Guba, 1981). Confirmability was accounted for by keeping consistency between the methodology and the methods. Furthermore, to achieve a confirmable study, the analysis process presented in Appendix E provides a detailed example of how the findings emerged from the data. Triangulating data, taking into consideration the viewpoint of different sources to minimize the bias, also increased confirmability.

3.7  Ethics
Two perspectives exist toward ethics in research, ethical implications toward the respondents and ethical implications regarding the results of the research.

Since qualitative research involves human interactions, ethical problems could appear (Silverman, 2013). General principles that most researchers agree on are voluntary participation and the right to withdraw, protection of research participants, assessment of potential benefits and risks to participants, obtaining informed consent, and not doing harm (Easterby-Smith et al., 2021; Silverman, 2013). Taking these general principles into account, a consent form and participant information sheet were sent to all participants prior to the interviews. This was done to inform the respondent about the handling of their data according to GDPR, inform them about their rights regarding participation in the study, and inform them about the intent of the study. Appendix C shows the GDPR form and participant information sheet. To further obtain informed consent, the respondents’
permission was asked for the recording of the interviews. Also, participants’ names and names of companies where the external actors’ work were left out.

The other ethical perspective regards the results of the research or as Easterby-Smith et al. (2021) refer to it, the protection of the integrity of the research community. Avoiding deception, communicating research honestly, avoiding misleading or false reporting of research findings, and ensuring accuracy and lack of bias in research results. In the current study, making sure that the research results were communicated honestly was done through the researchers checking each other’s work concerning the analysis of the data.
4. Empirical Findings

This chapter introduces the case and showcases the findings. The findings are divided into findings from reports, findings from interviews with internal actors, and findings from interviews with external actors. This is done to show the different perspectives that exist in the collected data.

4.1 Case Overview

Smart Built Environment is a Strategic Innovation Program, which is a joint initiative between, the Swedish Governmental Agency for Innovation Systems (Vinnova), the Swedish Research Council for Environment, Agricultural Sciences, and Spatial Planning (Formas), and the Swedish Energy Agency. In total, there are 17 Strategic Innovation Programs in Sweden. The purpose of the programs is to create conditions for Sweden to be competitive in the international market and make sure Sweden contributes to sustainable solutions (Andersson & Lázaro Morales, 2020; Holmberg et al., 2021).

Smart Built Environment focuses on how the construction sector can realize the opportunities that digitalization brings and spread information about new opportunities and changes in business models. Changing the built environment – with digitalization as the driving force – requires collaboration between actors, as the construction sector is fragmented into many different actors and processes (Andersson & Lázaro Morales, 2020). Hence, within the Smart Built Environment program, different actors like businesses, municipalities, authorities, industry- and interest organizations, institutes, and academia, collaborate to be able to utilize their knowledge within the program. Our study focuses on the area within Smart Built Environment that is called Value Chains and Business Models. This area handles questions about actor roles, competencies, working methods, and the organization of projects and processes (Andersson & Lázaro Morales, 2020).

Part of getting funding for an innovation program like Smart Built Environment requires getting evaluated so a decision can be made if funding should be continued. Two reports have been published regarding Smart Built Environment’s evaluation, after three and six
years of operation. The evaluations of Smart Built Environment are formative assessments, as it is an ongoing program, and aims to keep stakeholders up to date on which areas are working well and what areas need redirection. The consensus of the evaluations is that the program is fulfilling its purpose in bridging the gaps between actors and that the effectiveness of the program is high. Points of improvement mentioned are that the program’s logic is too complex and that the contribution to the national climate objectives needs to be better specified (Holmberg et al., 2021).

4.2 Summary of Empirical Findings

In our study, a total of nine reports from Smart Built Environment were analyzed. A list of the reports can be found in Appendix B. Also, seven interviews were conducted (Table 1), of which four were with employees and researchers connected to Smart Built Environment (internal actors), and three of the interviews were conducted with employees of construction companies that worked together with Smart Built Environment on projects (external actors). A total of three employees, from three different large construction companies, were interviewed.

<table>
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<tr>
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<td>Internal</td>
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<td>2021-04-20</td>
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<td>Internal</td>
<td>Project Leader/Researcher</td>
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<tr>
<td>3</td>
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<td>External</td>
<td>Head of Digitalization</td>
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<tr>
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<td>50 min</td>
<td>Internal</td>
<td>Coordinator</td>
</tr>
<tr>
<td>5</td>
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<td>45 min</td>
<td>External</td>
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</tr>
<tr>
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<tr>
<td>7</td>
<td>2021-05-05</td>
<td>40 min</td>
<td>External</td>
<td>Development Leader</td>
</tr>
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</table>

*Table 1 – Conducted interviews.*

The different themes that emerged in the data are summarized below. To show the different perspectives, the empirical findings are divided into the different sources: reports from Smart Built Environment, interviews with actors that are internal to Smart Built, and interviews with actors that are external to Smart Built. Explanations of specific
terms related to the construction industry that appear in the empirical findings and throughout the rest of the study can be found in Appendix D.

4.2.1 Reports

The reports of Smart Built Environment do investigations into pilot projects and interview different actors to study digitalization in the industry. These pilot projects are good examples of what is possible with current digital technologies. In report 2 (Appendix B) three pilot projects are discussed, which show that it is possible to deliver more value to all stakeholders in the building process through clearly specified digital deliveries (Borgström, 2018). The pilot project from Report 3 shows the benefits of using Building Information Modeling (BIM) in all stages of the construction process (Stenberg, 2020). Report 5 discusses examples of pilot projects, in which government organizations show the benefits of contracting and procuring in ways that facilitate innovation. Also, in reports 5 and 7 examples of collaboration between suppliers, to develop innovations are discussed (Malmgren, 2021; Zalejska-Jonsson et al., 2021).

Emerging topics in these reports are the influence of customers, the influence of the government, graduates as technology ambassadors, and industry collaborations through information streams. A further elaboration on these topics follows below.

4.2.1.1 Influence of Customers

Customers have the power to influence construction companies through procurements. A focus on price is the traditional driver of procuring. However, a focus on price inhibits innovation (Malmgren, 2021). The customer can force innovation by actors in the construction process by including functional requirements for innovation, including collaboration by the different actors and customers through the entire construction process, and including different compensation models (Andersson & Lázaro Morales, 2020; Malmgren, 2021). To be able to do this, customers need to have a good understanding of the construction value chain and the benefits and possibilities of digital technologies (Borgström, 2018; Malmgren, 2021). They have to be prepared to pay for the additional value that is delivered by the industry actors (Andersson & Lázaro Morales,
The possibilities for innovation in procurements exist but are inhibited by, among other things, culture and habits (Malmgren, 2021). In a lot of the pilot projects that are mentioned in the reports, government organizations act as a customer. Another inhibitor of innovation is the focus on single projects. When contracts span multiple projects the possibilities for innovation are greater, as progress can be made together over time and actors will see benefits arising for the entire process instead of only for their own cause (Jacobsson & Linderoth, 2018b).

4.2.1.2 Influence of the Government

The industry regulations are old and are not adapted to facilitate innovation and deal with digital technologies. New technologies come with legal issues, these also have to be dealt with in an appropriate way (Samuelsson, 2020). As already stated in the previous paragraph, the influence of customers through procurements and contracts is large. Making a legal framework around these procurements and contracts, which takes into account digital technologies, can make it easier to implement these technologies in projects (Samuelsson, 2020). Inspiration for this can come from neighboring countries, or initiatives taken by the EU (Ahlm et al., 2020; Samuelsson, 2020).

4.2.1.3 Graduates as Technology Ambassadors

Graduates give construction companies the possibility to increase their technological competencies. These graduates, who are generally technologically mature, can transfer their knowledge to more senior employees. However, they lack knowledge about the business and the industry. This is why a mutual exchange of knowledge is necessary between these two types of employees (Jacobsson & Linderoth, 2018a).

4.2.1.4 Basic Technological Infrastructure

There exists a basic technological infrastructure, that has the potential to supply rich data throughout all construction stages (Jacobsson & Linderoth, 2018b). Streams of information could facilitate more accurate data about buildings, which will result in more informed industry actors, customers, and society. Also, it can enable circular material
flows, and make the building process more efficient through increasing collaboration – between customers and industry actors– in all stages of the construction process (Ahlm et al., 2020; Borgström, 2018; Stenberg, 2020; Zalejska-Jonsson et al., 2021). It would essentially make boundaries between the different construction phases fade (Stenberg, 2020). Companies are generally reluctant to share information with other companies, as the question of who owns the information streams is an issue (Jacobsson & Linderoth, 2018b).

4.2.2 Internal Actors

The internal interviewees comprised of people working for, or with Smart Built Environment. Four interviews were conducted with a coordinator, researchers/program leaders, and a project leader.

Four overarching themes were identified during these interviews: the influence of the government, technological maturity, project-based development, and the construction value chain. These themes are described below and illustrated with some quotes from the interviews.

4.2.2.1 Influence of the Government

Most of the internal interviewees had a more nuanced view of the responsibility of the government. They identified that responsibility for change is more with the actors and less with the government. The example that was brought up the most during the interviews was that the sector likes to hide behind the public procurement act, as a barrier for change. However, this act gives customers the option to procure in different ways -as opposed to the lowest price- as well. If it is used in this way, it can be a driver. One thing that is for sure is that regulations should not hinder innovation, and the future needs to consist of a combination of industry initiatives and policy and regulations.
The industry probably says that the government is not doing enough, and when the government is trying to do something, then there is a lot of protest because then it's expensive. We need both regulations and initiatives from the industry.

(Interview 1)

“There will be a time not too far from now where we will look at each other and say why? How could we not use this technology? We don't need the authorities to do that.”

(Interview 4)

I think the actors [the companies] can't wait for the government either, they have to take their own responsibility for this. I think the government has done a lot of things by, for example, putting different demands on building materials and having climate declaration on materials.

(Interview 6)

The government is taking steps in the right direction, but regulations will always fall behind on technology. They invest a lot in sustainability and climate, so the pressure from their side is becoming higher. Apart from private investors, the government also funds research. Initiatives like Smart Built Environment try to gather the fragmented construction industry, while the results from their research are being used to make guidelines for the industry. Furthermore, actions are being taken concerning regulations about digital technologies as well, in which results from research are being used.

But this is just the first step to be able to demand these climate declarations and they are working further to see what we can do to facilitate the digitalization. So, there is quite a lot going on, but I also know that Boverket [The Swedish National Board of Housing, Building and, Planning] are waiting for a new assignment to develop this further. They have, I think approximately 20-25 people working with digitalization in their different regulations.

(Interview 1)
“We're involved in Nationella Riktlinjer [National Guidelines], where you define different scenarios for how you can communicate digitally, and then you can just point to one and say that's what we're doing in this project.”

(Interview 4)

I work at a nonprofit organization. It's been running for a little more than 10 years and it's an organization with members from all the construction industry in a wide sense. A lot of different companies, municipalities, governments, and authorities, who work with research and innovation in the built environment sector.

(Interview 6)

Some participants looked at other countries, where regulations regarding the use of digital technology are one or a few steps further, to motivate their answers. All the participants stated that there is room for improvement from the government’s side. The emphasis of their answers lies in the fact that the government can do more to facilitate innovation, as opposed to that the current regulations completely prevent actors from innovating.

I think there has been taken several steps towards digitalization, but not if you compare to some other countries where you have more directives from the authorities. For instance, for BIM models in building projects. I think you have it in UK, you have it in Estonia a lot of countries in Europe are working with this.

(Interview 1)

You should also know that a very common objection or a problem is its legal reasons. In order for the models to really be effective in the use, they have to be the legal binding document. Only when it is the legal binding document everybody will channel all their activities towards that model, but today it's not used that way because it's a high risk. They [architects and consultants] don't want to hand over the models to the contractor [construction company] because they're afraid that they could be used against them in legal settlements.

(Interview 2)
One thing that needs to be done is sort of define who owns the information in a BIM model. When you produce a blueprint and you send that out, you know that's the one that they build from. But who owns the model and who takes responsibility for what, in a model that 15 companies have worked on?

(Interview 4)

4.2.2.2 Technological Maturity

All interviewees indicated that to achieve the use of new technologies, the industry has to realize new business models and value chains. This means new roles and competencies in the industry. Right now, the low-hanging fruits of digital technologies are being picked. Most actors use digital technologies to benefit themselves, not for collective benefits, or benefits for the greater good. However, sustainability is becoming more of a driver, this also increases the pressure to use digital technologies. The implementation of small applications is decided at the company level and digital technologies are mainly used on a per-project basis. Technology change comes first, then people and habits change, then value chains, rules and regulations are the last things to change. Responsibility is passed down the value chain in projects (from architects and consultants to construction companies). Right now, tools are becoming more mature from the architects' and consultants' sides. It is only a matter of time before those are used to a larger extent.

But it has been very focused on developing –not the business model– but the way we work. Not to start from the vision that if you have a model and the information connected to it, how should the processes look? Because I feel that we are very good at improving the current processes, but not so good at changing the processes. As I think we need to do, to be able to really have the positive effects of digitalization.

(Interview 1)

You can say that the low-hanging fruits are in the internal processes. The lower risk, the easier to implement, the easier to use. The easier to see direct benefits –even though they are minor– lie within the internal operations. And that you can see examples of, but not too many examples of the other type of transformation.

(Interview 2)
What they [construction companies] can do, is that they can start these startups and ideas and foster them. They just have to change their mindset from, we do construction, and we bring in some software people to we're doing software which is primarily applied in construction. Even that we're not sure of, we'll see where we end up.

(Interview 4)

You have to think about what values you deliver and how you can deliver more value at the same time, a lot and totally different ways to get paid. You can see some of this in industrial housing, for example, companies like Lindbäcks or Moelven. They work with much more industrialized processes, and you can measure much higher productivity. So, it can be done and then you are selling products, they're not answering on bids.

(Interview 6)

Intelligent automation—which is a combination of robotics and artificial intelligence—was identified as a technology that might be applied in the construction industry of the future. This could support the off-site construction of industrial housing. Furthermore, participants also indicated that simulation in BIM models can provide the customers with different alternative solutions, from which they can choose.

4.2.2.3 Project-Based Development

The participants suggested that the project-based development of innovations inhibits digital transformation. It is expected that every project bares all the investments. A project-based development of long-term innovations is not feasible. It would make one project very expensive. Furthermore, the development of incremental innovations is largely dependent on the customers. The short-term needs can be satisfied by these incremental innovations, however thinking long-term will be the key for these businesses to be able to survive and prevent disruption. Companies cannot rely on their customers for these types of innovations. There has to be a sense of urgency that makes construction companies see that change is coming and face the hard reality that they have to change their business models. Developing digital technologies as a product, that will be used in
several projects, makes it easier to standardize them and makes them more economically feasible.

*I also think that you need to work with much more long-term cooperation between different parts [different actors in the value chain] because today you work often with new companies, new subcontractors, and so on for each project. And there is not so much taking care of the competence you build up from one project to another. It's more of the people working in the project take the competence with them, but not systematically.*

(Interview 1)

*It all comes down to sort of strategic collaboration then, so for instance a client and a contractor [construction company] for larger projects, they go together and they say that in this project we're going to use digital tools. So, they agree, but it's only in the duration of that project.*

(Interview 2)

*The logic of productification. Which is, we know that we are going to use this in a set of projects, so let's consider it a product that is recurring. That gives it a completely different economical logic, in terms of, where do we expect the funding for this to come from.*

(Interview 4)

*I think the client gets too much, responsibility. I think the client should be considered as a customer. It's natural that they don't have the competence. The innovation should come from contractor [construction company] peers and their consultants that have the competence, but they are organized in such a way and get paid in such a way, so they don't have the incentives to do this. So that's some kind of locked position.*

(Interview 6)
4.2.2.4 Construction Value Chain

Fragmentation of the sector is a big issue for the development and adoption of digital technologies. Today there are trust issues about the price between different actors, also ownership of data is a problem. These barriers prevent the effective collaboration that is needed to innovate. It results in a fragmented building process in which every actor does their own thing and tries to make as much money as possible. Because actors differ between projects, subcontractors always have to use different digital tools for each project. The tools used by each actor are largely incompatible. Long-term collaboration between actors is part of the solution to this, it can facilitate the systematical building of competency together. For this, all the actors involved have to dare to work in another way. There exist large projects today in which project-based collaborations facilitate the implementation of digital technologies.

*It was natural that you in the first phase when you were doing the early design and so on, you work with some consultants. When you had the contract and then start the detail design phase, the planning, and the building, then you change consultants, and sometimes they also change the architect. And I really think this is so insane because then you have new people into the project, they need to read into the material they need to start over. Also, they come with new ideas, and this could of course be good, but the reason for doing this was almost always to get the cost lower.*

(Interview 1)

*We have an industry that inherently lacks strong collaborative ties. That is a problem for digital transformation. On the other hand, when digital tools grow that creates stronger ties. So, the problem works both ways, but the solutions can also work both ways.*

(Interview 2)

The highest sense of urgency for change is at the levels that are higher in the value chain than the construction companies (developers, architects, consultants). This is because responsibility is passed down the value chain during the construction process. More specifically, their remuneration models are not suitable for a digital transformation. With the introduction of new digital technologies, the time spent on a project will not equal the
value that is created anymore. How construction companies' business models will change is harder to predict. There is the possibility that digital technologies will take away part of the value chain.

Architectural and technical, or professional services as one sometimes says, in construction and in any business will be very early in this challenge of artificial intelligence. They need to break their hypothesis that they've had over the years that the number of hours that they put in can be equated with the amount of value that they create, that needs to be broken. They need to do something completely different. Construction where you have to move rocks and timber and so forth is different, but I don't see why it shouldn't be, the rules of that game will be changed as well, it's just, it takes a longer time.

(Interview 4)

4.2.3 External Actors

Participants for the external interviews were three employees of three different large construction companies. Their positions in the companies were all related to digital technologies or innovation in general.

Topics that were touched upon are the influence of the government, incentives for the use of digital technologies, the construction value chain, and the implementation of digital technologies in construction companies. These topics are described below and illustrated with some quotes from the interviews.

4.2.3.1 Incentives for Using Digital Technologies

While –currently– digital technologies are mostly used to benefit the individual companies, the interviewees pointed out that sustainability should become more of a driver for the use of digital technologies. However, companies feel external pressure to innovate because of the activities of other actors in the industry. One reason for this is staying competitive with respect to other actors. In the future, other actors will pressure construction companies to share data to be able to collaborate. It was also mentioned that actors that are more technologically mature might reposition themselves within the value
chain, which would force construction companies to change as well. This is not happening right now but the interviewees did not think it will take much longer, as the industry is already becoming more digital, starting with the design phase.

“You do it [pilot projects] on some projects because you need to do it so you can stand on stages, saying that you also do it.”

(Interview 3)

Well, depending on from what perspective or with which lens you are looking at the problem. It [pressure] will come from internally because we want to make our processes more efficient and we want to be able to make sure that we are reusing knowledge. But it's also from an external perspective, as described earlier, we are one actor in the supply chain and we need to collaborate with the other actors/stakeholders and they will need the information in such way that they can use it in their processes.

(Interview 5)

There is a pressure, but I think that one tends to overemphasize the part that is looking only at digitalization. I would like to see digitalization as a means of helping us to solve other challenges, such as the climate challenge.

(Interview 5)

I would say that the pressure comes from us, internal pressure, and also that we see that our colleagues in the business do kind of the same things that we are doing. They also becoming more and more digital, so we need to keep up with them, of course.

(Interview 7)

We talked a lot about this in the project I mentioned in the beginning, where all kinds of businesses [from the construction industry] gathered and we talked about kind of the big picture for the future. We talked a lot about the environment and sustainability, that it will benefit from more smart use of digital tools.

(Interview 7)
There is value for the customer in the use of digital technologies. For the customer to be a driver they have to have the right competencies. These competencies are often lacking. One of the interviewees indicated that innovating purely for the customer is not cost-efficient, as it is better to make sure it brings value to all actors. This way the client does not have to bear all the costs.

“The customer is unfortunately not knowing what to ask for.”

(Interview 3)

The client … they want to be able to maintain their product in a good way in the future and to be able to do that there is an extra value of receiving, for example, a digital model that they can add on or use for their operation.

(Interview 5)

I think that if you're only making a model for the advantage of the client, you're not using digitalization in a very cost-efficient way. If you make sure that it brings value to all the actors, then you're not so dependent that the client pays an extra amount.

(Interview 5)

“Yeah, in some projects the client really has been driving the development absolutely. But it's not that common yet that the client has higher requirements for digitalization than we have ourselves.”

(Interview 7)

All participants indicated that more regulations are needed to create a platform for change. For example, making 3D models the legal document in the construction process, as opposed to the plans on paper. This will make the use of these models more effective, as all actors have to contribute to and work with the model. However, there exists a paradox, as some participants mentioned that regulations are also seen as additional costs that come on top of the costly building process.
A lot of laws and regulations are also not following a world that is changing. So, you can do it like in the UK. There the government has decided that every project needs to have a 3D model. You can do that without it making any sense, but it still doing something. It creates kind of a platform for change. So, I would like something like that also in Sweden.  

(Interview 3)

A new regulation will always render an additional cost in some way, and we also want to keep the cost level as low as possible because we have increasing building costs, so the higher demands we put the higher the cost. On the other hand, if we want to meet for example the Paris Agreement, we have to really enforce stricter regulations.  

(Interview 5)

Today we have the 2D drawings that is our legal document when we are out on the construction site. The 3D model is not a legal document yet, it’s more like a complement to the 2D drawings. But this has to change I think that the 3D model needs to be the legal document.  

(Interview 7)

4.2.3.2 Construction Value Chain

Remuneration models and lack of trust are seen as barriers. These are part of a larger problem, which is the scattering of the industry. Something else that was touched upon by one of the interviewees was that collaboration between competitors to develop digital solutions would make the process a lot easier. If everyone develops their own solutions, compatibility will be an issue. As of now, there is no possibility to do this. Technological knowledge of subcontractors is seen as a barrier by one of the interviewees. As a lot of the subcontractors work together with almost all big construction firms, they would have to learn to work with all the different solutions they use on their construction sites. However, the other interviewees indicated that this is inherent to the way the construction works and will be part of the digital transformation.
I think the industry, they ought to build it [digital technologies] because it's just ridiculous, the money [costs]. Also, that we share a lot of the subcontractor amongst us [the construction companies]. We will kill all these small companies with 10-12 different apps. It needs to be an industry system.

(Interview 3)

“And then of course you have the different levels of skills or capabilities, when it comes to digitalization, we still see that there are people who have a low level of digitalization capabilities and skills.”

(Interview 5)

So, I guess it will be a question about education and training in the projects. If you have a subcontractor, for example that are really used to work with another company, and we have a different tool. I guess we will have to educate and train this subcontractor so they can work with our system.

(Interview 7)

4.2.3.3 Implementation of Digital Technologies

Most of the participants indicated that a lack of technological knowledge outside of their departments inhibits the wider implementation of innovations. However, one of the participants mentioned that it is better now than five years ago. It becomes increasingly challenging when people with a lot of power have limited technological knowledge. As an example, one of the participants indicated that the new purchasing system within their company is not being used. It goes further than technological knowledge, for example, budgets to invest in digital technologies. Some of the participants mentioned that the problem with this wider implementation is that the pilot projects involve a lot of risks but also get a lot of support and attention. Later on, when the process has to be repeated for wider implementation, some of the risks are still there but the support is gone. This does not incentivize the people, that are responsible for the project, to work differently. On top of that, it is said that the risks become higher as profit margins get lower. It is essentially the old structures and business models of businesses that inhibit them from innovating.
People are stuck in their roles and keep holding on to technologies. The capability is there, but old company structures and business models inhibit innovation.

And of course, we work with some of the unique individuals that have that understanding. A lot of young people out on the sites understand this, but a lot of people with the power and the money don't understand anything and it doesn't matter how much you explain, because we have this bonus structure here that you get rewarded for sitting on your hands.

(Interview 3)

If a site manager is to introduce a new technology, which they know have been successful in one project, but you haven't seen like 10 tests or the result of 10 tests, and they associate it with a large risk and your manager says, okay you can try it, but it's up to you to keep the timetable, to keep the budget and so on.

(Interview 5)

It was not like that maybe five years ago, neither from our management or from all projects, but not now I would say that our management are really aware of this situation they want to do this and also our projects want to go this direction, they want to work more modern and more digital.

(Interview 7)

What is needed for a wider implementation - according to one of the interviewees - is a department that focuses on digitalization, with designated budgets and the possibility to use all projects as test projects. Other suggestions for improvements were making processes more standardized and efficient to allow focusing on other things, and new remuneration models. Also, in the future, one of the participants mentioned that they think new types of customers, revenue models, and value propositions will form.

“Therefore, you need to have a department that is free [for the development and implementation of digital technologies], they have the budget they just see the whole company as a testbed.”

(Interview 3)
Today we sell a number of hours or as many hours as possible. But if, for example, a structural engineering simulation takes 20 seconds, it's very difficult to send a number of hours. Even though those simulations are based on the many hours of development work. So in that way, you have to work with different types of value creation models for the client and you have to sell it in a different way, there I think we'll see a subscription model. We'll see, technical advisory models, and that can be reflected for the contracting business [construction company] as well because we could add data and collect data from a number of ongoing construction projects and sell that knowledge to a different type of customer.

(Interview 5)

We have an ongoing development project that aims for a more digital production, and we have started to pilot that project now. So, we have pilot projects that work in a certain digital way and after summer we will start to implement this new tool and these new methods in all our new projects.

(Interview 7)

The external interviews showed that -currently- a low amount of projects are digital in production. The digital technologies that are used are mobile phones to access drawings, handle communication, and quality inspection. These are all measures to improve efficiency. In the future, participants see 3D models becoming more apparent in the construction stage, as these are already widely used in the design stage. These models, in combination with sensors that collect data across the site, will have the potential to aggregate data about –for example– sustainability. This would make it possible to measure sustainability and have all the data that is available in one place. For this, it would be important that these solutions are user-friendly, as otherwise, it becomes too difficult to teach the other actors how to work with them. Benefits for the environment were said to be the measuring of emissions.

“We don't scale anything. We do a lot of piloting and reporting ... it doesn't matter as long as it doesn't scale.”

(Interview 3)
Well, I think that digital tools and sensors are necessary for us to be able to become more sustainable. Because you will need to be able to measure the improvements and the effects of the improvement. So, things like collecting CO2 emissions from the materials we buy. We can also, of course, keep track of the indoor climate, the use of energy, use of warm water. So, keeping track of the important parameters and also report scope 1, scope 2, and scope 3 emissions.

(Interview 5)

They use mobile phones to get access to documents, drawings, 3D models, and so on. They also use mobile phones to handle communication to handle quality inspections and so on. But that is far from every project, I think that we have maybe 600 or 700 projects up and running continuously within my department in Sweden only. So, there are many projects and maybe like 10% of them are digital in production up until now.

(Interview 7)
5. Analysis

This chapter describes the analysis of the empirical findings. The reports and interviews with different actors are analyzed separately. This is done to show the different points of view and provide a continuous confrontation between empirical data and the frameworks. The chapter concludes with a description of the resulting frameworks.

As explained before in section 3.5, analyzing the empirical data was done in three phases. First, reports were analyzed. After that, the interviews were analyzed in two rounds; based on the sub-unit of analysis – actors internal or external to Smart Built Environment. Figure 3 shows the process of the analysis. Depending on the type of data, reports were read, or interviews were transcribed. Coding was done to highlight important pieces of data and bring structure to the data. Conceptualization was accomplished by categorizing and sub-categorizing the coded data. The basis for the categories (Figure 4) was formed by the frameworks that were developed from existing literature (Figures 1 and 2). As the analysis progressed, new sub-categories were introduced to expand the frameworks with new information. The data belonging to each sub-category was then aggregated to form concepts. Next, the concepts were used to identify links between categories and sub-categories. Finally, the frameworks were updated with the identified categories, sub-categories, concepts, and links. The frameworks were updated this way three times, to result in the final frameworks, which are shown in Figures 12 and 13 in section 5.3. Below, the three stages of the analysis and the final results are described. A more detailed example, of how the analysis was executed, can be found in Appendix E.
5.1 Analysis of Reports

During the analysis of Smart Built Environment’s reports, five new sub-categories were identified from the data and one of the sub-categories was changed. On the other hand, the reports gave no confirmation of private financing or financial stakeholders being a part of the socio-technical regime that influences the digital transformation of construction companies (Figure 5). First, the interactions in the socio-technical system that were identified during the analysis are described, using the framework for the analysis of interactions in the socio-technical systems. After that, the changes to business models are discussed, using the framework for the analysis of changes in the business models. The resulting frameworks from this round of analysis can be found in Figures 6 and 7.
On the socio-technical landscape level (Figure 6), apart from the global climate, EU policy and regulations and foreign policy and regulations were found to influence the socio-technical regime as well. These are in their turn also influenced by the socio-technical regime.

In the socio-technical regime (Figure 6), it was found that customers play a big role in the implementation of innovations in the construction industry. Customers exercise their influence through procurements. Including functional requirements for innovation, collaboration, alternative compensation models, and projects with a longer duration are all drivers of innovation that influence the business model mediation space. Furthermore, including collaboration between different industry actors in the procurement also influences the industrial networks. To enable this, the different suppliers need to be clear toward the customer about what the value is they are paying for, and customers need to be clear about their demands. This means that industrial networks also influence the customer. The pilot projects show that driving innovation through procurements is possible, however, it is hindered by culture and habits. Also, public policy and regulations in Sweden are seen as influential on the level of the socio-technical regime. The regulations determine how public procurements are executed, while policy can be responsible for how government organizations procure their projects and act as an example. This means that the government also influences innovation driven by customers.
The existing technology infrastructure is spread out across the entire construction value chain. This has the potential to facilitate information deliveries, which benefits customers and society. While there exists a basic technology infrastructure, spanning the value chain, actors closer to the design process are more mature in the use of these technologies. As mentioned before, collaboration by different actors in industrial networks can result in fading boundaries between the different construction phases. This can make the actors that lag behind see the benefits of the use of digital technologies. Government regulations also influence the business model mediation space directly by enforcing regulations that directly affect construction companies e.g., the act on climate declaration.

Graduates are seen as an important source of technological knowledge, as their education provided them with important know-how about new technology in the industry. Graduates are found to increase the overall technological knowledge on the regime level, which influences the business model mediation space.

Figure 6 – Framework for analysis of interactions in the socio-technical system, after analyzing the reports.

In the detailed view of the business model mediation space (Figure 7), continuous streams of information through a Building Information Model (BIM) was identified as a digital
technology that could be further exploited in the future. Reduced energy consumption of buildings through the constant monitoring of the building in the BIM model was seen as a benefit for the environment. Also, BIM models have the potential of providing information that can be used for the recycling of building materials.

In the business model (Figure 7), other actors – along the construction value chain – become increasingly important as key partners. Apart from collaborating more with these key partners, construction companies’ key activities will shift toward being more involved in the design process and contributing to the BIM model. Furthermore, to be able to benefit from the technological knowledge of graduates, they must be assisted by more senior employees. The senior employees know the business and value chain, while the graduates can contribute with their knowledge about digital technologies. What will change in the key resources is that the human resources will become people with a more technical profile. While companies will also depend more and more on these technological resources. This will cause changes in the roles people fulfill within the company and can cause tension among the employees. Apart from regular values that are delivered to the customer, information delivery will be an additional value. This will also mean that the connection between client and company will become closer, as customers will be more informed and involved. The customer will have to pay for this additional value. To do this, the remuneration structures will have to change. Investments in new digital technologies are necessary within the company.
5.2 Analysis of Interviews with Internal Actors

The analysis of interviews with actors internal to Smart Built Environment revealed two new sub-categories on the level of the socio-technical regime. All the categories and sub-categories that were used for this part of the analysis are shown in Figure 8. First, the interactions in the socio-technical system that were identified during the analysis are described, using the framework for the analysis of interactions in the socio-technical systems. After that, the changes to business models are discussed, using the framework for the analysis of changes in the business models. The resulting frameworks from this round of analysis can be found in Figures 9 and 10.

Figure 7 – Framework for analysis of changes to the business model, after analyzing the reports. This framework shows the business model mediation space in more detail.
On the level of the socio-technical regime (Figure 9), the interviews with internal actors showed that the influence of culture and habits is even greater than what was initially indicated in the reports. What influences the culture and habits is the structure of the construction sector, hence the link between industrial networks and culture and habits. Furthermore, the culture and habits influence not only the relationship between construction companies and their customers but also their relationships with the other actors in the industry (industrial networks), and the way digital technologies are adopted by the construction companies. This can be seen from the change in actors from project to project and project-based focus in the development of digital technologies, respectively. Also, the much-discussed application of the public procurement method – in which the actor with the lowest price gets the job – is an example of how culture and habits influence the relationship between customers and construction companies.

Results from research influence the construction companies and other actors in the value chain. They also exert influence on these research initiatives by participating in them. Research is funded by the government or private financers. The research programs also influence the government with the results. This indicates a more indirect influence of actors in the construction industry on the government, rather than the direct influence that was proposed in the initial framework (Figure 1).
It also became clear that the government –through regulations– influences the culture and habits of the construction industry. Although the current regulations regarding procurements allow for digital innovations to be used, the industry sees it as a barrier to innovation.

Industrial networks will –in the future– influence the business model mediation space of construction companies, as the actors higher in the value chain will start changing first.

![Figure 9 – Framework for analysis of interactions in the socio-technical system, after analyzing the interviews with internal actors.](image)

In the detailed representation of the business model mediation space (Figure 10), Intelligent Automation and another use for BIM models were identified as future technologies. The additional benefits for the environment that were mentioned, comprised the reuse and recycling of materials and simulations that can optimize sustainability.

In the business model (Figure 10), role changes will have to happen. Digital technologies will make certain positions obsolete, while new roles with other competencies will be needed. Examples of these are operators of the new technology, product developers, and software developers. Furthermore, the development of new technologies as a product –as opposed to developing on a project basis– will make the solutions more standardized and
economically feasible. Also, industrialization of the building process will have to happen to reap the benefits of intelligent automation. The implementation of digital technologies to benefit sustainability and collective benefits will have to be done. This will help to solve sustainability and compatibility issues. Therefore, long-term collaborations between actors are needed. The additional values that new technologies will bring for the customer are that less time will be spent on the construction site and that simulated alternatives can easily be compared.

![Figure 10 – Framework for analysis of changes to the business model, after analyzing the interviews with internal actors. This framework shows the business model mediation space in more detail.](image)

**5.3 Analysis of Interviews with External Actors**

The analysis of the interviews with actors that are external to Smart Built revealed one new sub-category. All the categories and sub-categories that were used are presented in Figure 11. First, the interactions in the socio-technical system that were identified during the analysis are described, using the framework for the analysis of interactions in the socio-technical systems. After that, the changes to business models are discussed, using the framework for the analysis of changes in the business models. The resulting frameworks from this round of analysis can be found in Figures 12 and 13. These are also the final versions of the frameworks for this study.
On the level of the socio-technical regime (Figure 12), the mutual influence between the construction firms and the rest of the value chain—signified by the arrows between the business model mediation space and industrial networks—was confirmed again by the pressure from other actors in the construction value chain to change, and the benefits that would come from developing digital solutions together. The co-creation of different actors could also lessen the influence that culture and habits exert on the relationship between customers and construction companies. When there are benefits from this co-creation for all parties involved, not all costs have to be recovered from the customer. Also, the link between policy and regulations and culture and habits was confirmed through the paradox that exists. According to the interviewees, there is a need for a legal framework—however—regulations are also seen as additional costs.

On the level of the business model mediation space (Figure 12), the sub-category organizational structure was introduced. The influence of organizational structure on the link between digital technologies and the business model indicates how the structure of organizations influences the wider adoption of digital technologies. Besides that, organizational structure also influences the culture and habits, as it makes people hold on to their roles within the organization and hold on to old technologies.
In the detailed view of the business model mediation space (Figure 13), the digital technology that was discussed is the use of sensors, which will provide richer data in combination with Building Information Modeling. It will make it possible to measure emissions and other environmental factors objectively, hence benefiting the environment by enabling companies to see the real impacts of their decisions.

In the business model (Figure 13), it was identified that the problem of lack of knowledge outside of the technical department could be tackled by investing in the education of employees. To support the wider implementation of digital technologies, putting the risk not on one person could make it easier to do this. Furthermore, collaboration between actors in the development of digital solutions also spreads the risk and makes compatibility issues and lack of knowledge by subcontractors less of an issue. There will be less diversity in the digital tools that are used. These new digital tools can help construction companies in attracting new types of customers, and give them the chance to change their revenue streams through technical advisory services or subscription models.
Figure 13 – Framework for analysis of changes to the business model, after analyzing the interviews with external actors. This framework shows the business model mediation space in more detail.
6. Discussion

This chapter discusses the empirical findings and analysis by consulting existing literature. First, the interactions in the socio-technical regimes are discussed. The chapter ends with a description of the changes to construction companies’ business models to facilitate a sustainably driven digital transformation.

The three parts of the analysis – reports, internal actors, and external actors – made it possible to penetrate the issue of the interactions between established construction companies and the rest of the socio-technical system they are part of, and the necessary changes in business models to facilitate digital transformation, with environmental sustainability as a driver. The final frameworks are shown in Figures 12 and 13, respectively.

From the final framework that represents the interactions in the socio-technical system (Figure 12) and the corresponding parts of the analysis, we see that the interactions between the incumbents and the rest of the socio-technical systems are centered around the interactions between the construction companies’ business model mediation space, industrial networks, customers, culture and habits, and public policy and regulations. The first three of this list are all the actors involved in the construction value chain. The latter two – culture and habits, and public policy and regulations – are the rules that exist within the regime and that are followed by these actors. As described by Geels (2002) and Schot and Geels (2008), it is these rules that make the regimes stable. This can also be seen from the present analysis, as culture and habits get fueled by the structure of organizations and value chain, and by the notion that current rules and regulations inhibit the use of digital tools. The culture and habits, and public policy and regulations affect the relationships between the three parts of the socio-technical regimes that make up the construction value chain, making the regime stable. However, as discussed by Geels (2014), policies and regulations have the power to destabilize regimes. This could explain the paradox of the need for policy and regulations, but the high costs that accompany them. The construction companies also see that they have to change, but the high cost that destabilization brings with it – among other things like changes in the way construction companies work – makes
them resist. The collected data did not show the existence of alliances, which consist of politicians and incumbent firms, as described by Geels (2014). Alliances can stabilize the regime even further.

According to Geels (2002), only incremental innovations emerge from stable regimes. This can be seen from the digital technologies that are currently being implemented. These solutions are aligned with the socio-technical regime, respecting the structures of organizations and value chains, remuneration models, etc. As mentioned by Ludeke-Freund (2020), and Bolton and Hannon (2016), agency of incumbents in transitions of regimes – caused by innovations that are not incremental – is only possible when business models are aligned with the changes that are caused by these innovations. In the business model mediation space, we can see that the culture and habits, and policy and regulations also influence the adoption of digital technologies. If the regime would be weakened, an alignment like this could be possible. Destabilization of the regime would essentially facilitate an easier alignment for the industrial networks and customers as well.

The final framework with the suggested changes for business models of construction companies is shown in Figure 13. These changes are perceived as necessary to facilitate a digital transformation of the business models. In existing literature – about the digital transformation of the manufacturing industry – Paiola et al. (2021) and Ciliberto et al. (2021) describe that manufacturing firms change their value propositions toward the sale of services instead of products, using digital technologies. The analysis did not show a change from selling products to selling services in the future. However, the same changes that are accompanied by servitization in the manufacturing industry were seen as essential for a successful digital transformation in the construction industry: changes in revenue streams, cost structures, activities, and relationships with partners. One of the possible explanations why servitization was not discussed is that, right now, only the benefits of digital technologies for individual companies are exploited outside of pilot projects, while the existing literature describes the digital transformation of manufacturing firms that are driven by sustainability. The construction companies know that certain parts of their business models need to change, but the current maturity of these changes does not allow them to reflect on the changes in such a specific way.
Also in Figure 13, the digital technologies that—according to the reports and interviewees—will become more prominent in the future and the possible benefits for environmental sustainability are shown. The business model can be seen as the bridge between those parts. As mentioned by Chesbrough (2010), the technologies themselves bring no value to companies, unless the values can be captured, created, and delivered through the business model. On the other hand, existing literature describes how it is unclear how businesses capture economic value from sustainability, but that digital technologies are necessary to deal with environmental challenges and stay profitable in the future (Bican & Brem, 2020; Bocken et al., 2014; Gregori & Holzmann, 2020). From the collected data and corresponding analysis, we can see that construction companies start to realize the potential of digital technologies in solving environmental challenges. However, what they do not seem to realize is that this combination—digital technologies and environmental sustainability—is also essential for their survival.

Paiola et al. (2021) state that network orchestration, in which co-creation between partners happens, is necessary for a digital transformation driven by sustainability. This can be seen from the proposed changes to the business model (Figure 13) as well, as collaboration and co-creation will increase the benefits for all involved partners including the customer. Furthermore, environmental sustainability will benefit from the free flow of data between the actors in the ecosystem. Chesbrough (2010) found that to facilitate a business model transition, companies should change their organizational processes and adopt an efficient approach toward business model experimentation. The proposed changes to the business model also reflect this, as the project-based focus of adopting digital technologies is seen as less efficient than a product-based approach that has the possibility to utilize the entire company as a testbed. Furthermore, industrialization of the construction process—or off-site construction—was suggested in the changes to the business model. This change would make the construction industry lean closer toward the manufacturing industry, an industry in which most of the research for digital transformation has taken place and that has shown that digital transformations are possible.
7. Conclusions

In the following chapter, the main conclusions of the study—related to the purpose of the thesis and the research questions—are presented. Followed by implications of the study for theory and practitioners. The chapter ends with a discussion of the limitations and suggestions for future research.

The purpose of this study was to contribute to socio-technical systems theory by investigating how interactions in the socio-technical regime can help in transforming incumbent construction firms and make them more environmentally sustainable.

From our findings, we can conclude that the interactions in the socio-technical regime, that can influence construction companies to digitally transform their business models, are the ones that control the relationships between the actors in the construction value chain and the adoption of new technologies. Namely, the culture and habits, and public policy and regulations. Actions taken by the government could destabilize the regime, by artificially influencing the relationships between actors in the construction value chain. Moreover, they have the possibility to influence the adoption of digital technologies. This may come at a cost, as repercussions for established firms can be big. A better alternative would be industry initiatives, which work with collaboration or even co-creation. This is a means to transcend organizational boundaries, hence lessening the influence of culture and habits on their relationships. Realistically, a combination of these two could be a solution. The findings of this study suggest that regulations tend to fall behind on technology, while the undesirable impact of regulations will be less when industry actors work proactively.

The changes to business models that need to happen to facilitate a digital transformation of construction companies, driven by sustainability, are centered around the following key activities: long-term collaborations, product-based development, co-creation with partners, and using digital technologies as a use case for sustainability. The latter is an important realization the construction companies need to make, as their future existence depends on this. Customer demand was identified as a possible driver for sustainability.
through the use of digital technologies, however, the construction companies should not depend on the customer demand to make a change like this. Due to customer knowledge about subjects like this being low, it is better to work proactively and see how value can be captured for the customer. By treating digital technologies as a product and working on development together with partners in the value chain, greater value can be created, and the economic rationale for development will change. Costs can be spread over multiple projects and between actors, while the benefits of technologies outside of the individual firms can be exploited. Looking at the empirical evidence, it is expected that the value from these digital technologies that will be delivered to the customer will be the digital delivery of information, providing alternative solutions, and less time spent on site. Furthermore, they will also benefit by having a greater influence on the project. To capture this data, construction companies will most likely have to diversify their customer base and use revenue models in which these customers pay for the value delivered, rather than the time spent on a project.

During the interviews with actors that were external to Smart Built Environment, the topic of disruption was often touched upon. With the deterioration of the global climate and digital technologies that offer new possibilities, it is not a question of whether a transition will happen but when and how it will happen. However, the thought behind agency in transitions is to not get disrupted. Agency means surviving a possible future transition of the socio-technical regime. Construction companies will have to align their business models with the changes an environmental sustainably-driven digital transformation of the industry brings. For this to be possible, the socio-technical regime –in which the incumbent construction companies are embedded– has to be destabilized. Due to its interconnected nature, the destabilization of the regime also depends on all other parts of the socio-technical regime. Not knowing when and how this destabilization will come makes the future of established construction companies very uncertain. Nonetheless, by taking action construction companies can help in shaping the transition and perhaps secure their survival.
7.1 Implications for Theory

The study contributes to socio-technical systems theory by shedding light on the less studied subject of agency in regime transitions, through the incorporation of the concepts of business models and digital transformation. Building on existing research, the interactions in the socio-technical regime that affect construction companies in their digital transformation were explored. Also, the changes to business models that are necessary to facilitate a digital transformation –driven by sustainability– were identified.

The theoretical implications are twofold. First, to facilitate agency by actors in the socio-technical regime, the explicit and implicit rules that are present within that regime have to be weakened, by the collaboration of different actors in the regime and governance. Second, to facilitate a digital transformation driven by sustainability –hence show agency– the actors themselves have to align their business models with the changes those new digital technologies bring to be able to become more sustainable. To reach alignment incumbents have to look at the possibilities new digital technologies provide while disregarding the current way of working. Only this way it is possible for established firms to go from doing incremental innovations to doing more radical innovations.

7.2 Implications for Practitioners

In a time of constant change due to the emergence of digital technologies, companies need to be aware of new opportunities and challenges that arise from that. We believe that construction companies need to align their business models with the changes an environmental sustainability-driven digital transformation of the industry brings to survive the transition.

This study presents two main implications for managers of construction companies in implementing digital technologies in their business models. The need to work proactively in realizing how value can be captured for the customer, instead of waiting for the customer to recognize that. Also, working on the development of digital technologies together with partners in the value chain, to create greater value. Furthermore, the interconnectedness of actors in the socio-technical regime means that these implications are also valid for the other actors in the construction value chain. As changes first happen
higher up in the value chain, the need for change is currently even more apparent for consultants and architects.

For governments, the implications are that the most important goal of regulations should be that current regulations do not hinder the development of digital technologies, while in new regulations attention should be paid to combining digital technologies and sustainability.

7.3 Limitations

In fulfilling the purpose of our study, significant findings concerning interactions in the socio-technical regime and their impact on the digital transformation of established construction companies have been found. Nevertheless, some limitations are apparent in our study. One limitation concerns the transferability and whether our findings could apply to other industries, as the framework and the emerging model are based on data related to digital transformation and business models within the Swedish construction industry. Different geographical locations can have different levels of technological knowledge, different cultures, and different rules and regulations. Therefore, it is important to consider the uniqueness of socio-technical systems, depending on their contexts.

Next, another limitation can be seen in the sampling strategy for interview participants and the case. By only interviewing people connected to Smart Built Environment, the findings show that people often share the same opinion, and knowing if that is because they have taken part in the same program or if it is the consensus in the industry becomes hard. A case study with multiple cases and more units of analysis could have lessened those issues.

Finally, our research only looks at the connection between digital transformation and environmental sustainability, not the other two parts of the triple bottom line: societal and economical sustainability. It should be noted that these three parts are equally important for any business to be fully sustainable.
7.4 Future Research

Hopefully, our findings can inspire future research in further exploring the digital transition towards sustainability, as several challenges remain. This study is solely based on collected data related to the transition of business models in the Swedish construction industry, it would be interesting for future research to use a similar research design and framework, and apply it to other countries. Which would enable cultural and geographical differences to be observed and could generate valuable findings in the field of digital transformation of construction companies. Another suggestion is testing the transferability of the study and applying the research to other industries.

The literature about digital transformation is continuing to increase but there are still several areas to be investigated. Another interesting angle to explore is looking at the process of digital transformation over time, for instance by doing a single case study over a longer period, to get insights into how interactions between actors influence the various stages in the process.

The findings show that collaboration and co-creation could be a way to surpass organizational boundaries and reduce the influence that culture and habits have on relationships. Future research could examine that possibility further, and how co-creation influences a digital transformation driven by sustainability. Furthermore, additional research is needed to explore the different actors’ connectivity and dependencies within the socio-technical system. For instance, including the perspective of other actors in the research like the government and the customers, to better understand the relationships within the socio-technical regime. Relating to this is also research with a greater focus on the existence of alliances between politicians and industry actors.

Also, the influence of organizational structure on the adoption of digital technologies was identified. Future research could further explore the effects of leadership and organizational structure on digital transformations.

Disruption was a recurring topic among interviewees, although outside the scope of our study, future research could focus more on the development of radical technologies in socio-technological niches that can disrupt the construction industry.
8. Reference list


9. Appendices

Appendix A – Interview Guide

Introduction (Internal & External)
- Could you briefly explain your role? Your involvement with Smart Built Environment?

Questions about socio-technical regime and landscape (Internal)
- Have you seen any changes in how contracting companies work, that can be related to the research Smart Built does?
- What are the drivers for implementing digital tools for construction companies?
- What are the barriers for implementing digital tools for construction companies?

Questions about socio-technical regime and landscape (External)
- Is there a pressure to digitalize processes in the construction industry?
- If you work with innovation or R&D, who gives incentives to do this?
- What are the drivers and barriers for implementing digital tools for construction companies?

Questions on business models (Internal)
- Which digital tools are being used by contractors?
- Do you feel like there is a need for construction companies to change their business models?
- Do you see any trends in the use of digital tools in the industry that could have an impact on the business models?

Questions on business models (External)
- Which digital tools are being used by contractors?
- Do you feel like there is a need for construction companies to change their business models?
- Do you see any trends in the use of digital tools in the industry that could have an impact on the business models?
- Have you seen changes in the business models of contractors over the years?

Questions about how digital technologies are part of the climate solution (Internal & External)
- Is there a benefit for the environment in the use of digital tools?
- Would you say that the industry is doing enough to meet sustainability goals?
- Is the government doing enough?
## Appendix B – List of Analyzed Reports from Smart Built Environment

<table>
<thead>
<tr>
<th>Nr</th>
<th>Year</th>
<th>Swedish and English Title</th>
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| 1  | 2018 | Att gå från ord till handling: Nyutextereras potential för att stödja digitaliseringsdriven innovation i byggbranschen.  
(From word to action: the potential of newly graduates to support digitalization-driven innovation in the construction industry.) |
| 2  | 2018 | Effektivare informationshantering med i-leveranser: värden som skapas med specifiserade digitala leveranser och hinder.  
(More efficient information handling with i-deliveries: value creation with specified digital deliveries and barriers.) |
| 3  | 2020 | Facility information modeling – fokus på energibesparingar i fastighetsförvaltning  
(Facility information modeling – focus on energy-savings in facility management) |
| 4  | 2018 | Hinder och drivkrafter för en digitaliseringsdriven branschutveckling  
(Barriers and driving forces for a digitalization-driven industry development) |
| 5  | 2021 | Upphandling som främjar innovation: Framgångsfaktorer och barriärer i samhällsbyggnadsbranschen.  
(Procurements that facilitates innovation: success factors and barriers in the built environment sector.) |
| 6  | 2020 | Digitala informationsflöden i byggprocessen: Vilka värden kan ett obrutet informationsflöde mellan material, tillverkare och fastighetsägare skapa?  
(Digital information flows in the construction process: what value can an uninterrupted flow of information between materials, manufacturers and facility managers create?) |
| 7  | 2021 | Digital adoption och värdeskapande i fastighetsförvaltning: ett systemperspektiv  
(Digital adoption and value creation in facility management: a system perspective) |
| 8  | 2020 | Digitala affärsmodeller – revidering av AB 04 och ABT 06  
(Digital Business Models – revision of AB 04 and ABT 06) |
| 9  | 2020 | Syntes Värdekedjor och affärsmodeller 2016-2018  
(Synthesis Value Chains and Business Models 2016-2018) |
Appendix C – Participant Information Sheet and GDPR Consent Form

Participant Information Sheet

'You are being invited to take part in a thesis study. Before you decide whether or not to take part, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully.'

The purpose of this master thesis is to give insights into how businesses in the construction industry transform their business models to meet sustainability goals, the interviews will be used as empirical findings contributing to the research. The study takes place from January to June 2022.

'It is entirely up to you to decide whether or not to take part. If you decide to do so, you will be given this information sheet to keep and will be asked to give your consent.' All the information that we collect about you during the course of the research will be kept strictly confidential. You will not be able to be identified in any ensuing reports or publications.'

Under GDPR you have the following rights over your personal data:

- **The right to be informed.** You must be informed if your personal data is being used.
- **The right of access.** You can ask for a copy of your data by making a ‘subject access request’.
- **The right to rectification.** You can ask for your data held to be corrected.
- **The right to erasure.** You can ask for your data to be deleted.
- **The right to restrict processing.** You can limit the way an organisation uses your personal data if you are concerned about the accuracy of the data or how it is being used.
- **The right to data portability.** You have the right to get your personal data from an organisation in a way that is accessible and machine-readable. You also have the right to ask an organisation to transfer your data to another organisation.
- **The right to object.** You have the right to object to the use of your personal data in some circumstances. You have an absolute right to object to an organisation using your data for direct marketing.
- **How your data is processed using automated decision making and profiling.** You have the right not to be subject to a decision that is based solely on automated processing if the decision affects your legal rights or other equally important matters; to understand the reasons behind decisions made about you by automated processing and the possible consequences of the decisions, and to object to profiling in certain situations, including for direct marketing purposes.

You should also know that you may contact the data protection officer if you are unhappy about the way your data or your participation in this study are being treated at dpo@ju.se

Thank you for reading this information sheet and for considering whether to take part in this research study.'

**Contact details for further information**

**Thesis student**
Mathijs Doemen  Dama21aq@ju.se

**Thesis student**
Fanny Hansson  Hafa21xo@ju.se

**Thesis supervisor**
Jerker Moodysson  Jerker.Moodysson@ju.se
GDPR Thesis Study Consent Form
Required by European Union General Data Protection Regulation 2016/679

GDPR Consent for Digital Transformation and Agency in Businesses’ Journey Towards Sustainability

Please tick the appropriate boxes

Taking part in the study
I consent to JIBS processing my personal data in accordance with current data protection legislation and the data delivered. ☐ ☐

I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason. ☐ ☐

My signature below indicates that I choose to take part in the thesis study and consent to JIBS treating my personal data in accordance with current data protection legislation and the data delivered.

_________________________  _______________________  ________________
Name of participant [IN CAPITALS]  Signature  Date

Thesis contact details for further information
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[Mathijs Daemen, +3248306096, dama21aq@student.ju.se]

Version: January 2020
Appendix D – Explanations of Jargon from the Swedish Construction industry

**Act on Climate Declarations** – Act for new buildings in Sweden, applying as of 1 January 2022, which means that the impact on the climate must be reported for new buildings that need a building permit (Boverket, 2021).

**Building Information Modeling (BIM)** – A digital form of construction, that brings together technology, process improvements, and digital information (ECSO, 2021).

**Boverket** – The Swedish National Board of Housing, Building, and Planning.

**Built Environment** – The product of construction, the human-made space in which people live, work, and recreate including buildings, parks, public spaces, and infrastructure (ECSO, 2021).

**Construction Value Chain** – Refers to all the upstream and downstream activities of a construction project that add value for the end-user. Involves activities in all phases of a construction process, including planning, design, engineering, construction, and operations.

**Public Procurement Act** – The rules that are governing how the purchasing process in public sector organizations is conducted. The purpose of the act is to prevent corruption and discrimination whilst promoting the effective use of public funds (Boverket, 2022; Upphandlings Myndigheten, n.d.).

**Sensors** – Any device that enables collecting data and monitoring the performance of any aspect of a construction project, during the whole building lifecycle including operation and maintenance (ECSO, 2021).

**Scope 1, Scope 2, and Scope 3** – Greenhouse Gas Protocol (GHG) emissions, an established standard to account for and report emissions, are classified into three “scopes,” scope 1 (direct emissions), scope 2 (indirect emissions), and scope 3 (all other indirect emissions that occur in a company’s value chain) (GHG Protocol, n.d.).
**Industrial Housing** – Residential building that is constructed using one or more modules, which are fabricated off-site.
Appendix E – Example of the Analysis Process