



**LUND UNIVERSITY**  
School of Economics and Management

# Innovation in the Construction Sector

How contextual factors affect innovation

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## **Abstract**

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*Key words:* Construction sector, Innovation, Contextual factors, Green Building, Network Theory, CoPS

*Purpose:* Which contextual factors are affecting the innovation process in the Swedish construction industry? How does this contextual reality affect the innovation process?

*Methodology:* The project is based upon an abductive approach by the data gathering method of semi-structured interviews.

*Theoretical perspectives:* In order to understand and identify critical factors it has been essential to include theories from the following fields: CoPS, Network Theory, Regulations and Standards

*Empirical foundation:* Stakeholders in the construction industry; two construction companies, an architect, a real estate firm, a security firm

*Conclusions:* Regulations have an affects innovation but not as strongly as firstly thought. The green-building (standard) concept is pushing the industry in the environmental direction, the users heavily influence the industry, high investments and low margins is making the industry conservative, knowledge-learning are low due the unique nature of each project, competitive advantage through an effective process by an integration of the network.

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# 1. Introduction

## 1.1. The Construction Sector

The Swedish housing market is characterized by underdevelopment and scarcity (Jagrén et al, 2005). Among other things, this is due to high cost for construction caused by high regulatory demands as well as an inefficient market for supplies (Pan, 2009). On top of this, there is low support from the government that formerly heavily subsidized construction (Jagrén, 2005), which makes construction relatively more expensive than what it has been historically. According to Wong et al (2010) the efficiency and the innovation rate in the construction business is low and needs to be increased in order to cope with increasing demands from customers and regulators. There is an apparent trend both among customers and legislators that demands will be higher in the future. Customers are increasingly raising their expectations what should be provided from a new apartment or construction and legislators are increasing the stringency of current laws (Jagrén et al, 2005).

Additionally the deregulation and liberalization of the EU markets have increased and will most likely continue to increase the competition from foreign construction firms (Jagrén et al, 2005). Swedish construction firms are already facing a stronger pressure from, among other, Danish, German and Polish companies that are penetrating the Swedish market (Jagrén et al, 2005). However, all the changes that are evident on the construction market can also be seen as an opportunity if a company has the ability to present top solutions to the problem. The company that is able to show the market that it has the best solution for a more energy efficient building will have large opportunities to increase sales and gain market share from competitors.

All these factors increase pressure on domestic firms to enhance the efficiency by improving their processes, products and business models. According to Pan (2009), it is essential that companies that are active in the construction business implement long term strategies that promote innovation in the organization, both to cope with increasing expectations and to gain a competitive advantage against their rivals. But in order to implement a long term strategy for increased innovation it is vital to know how innovation works in the construction industry; what makes it contextually unique and this affects the innovation process.

## 1.2. A complex industrial structure

Hobday (1998) argues that complex markets behave substantially different from markets of mass-produced goods. He asserts that the construction industry can potentially be described as a complex market. It is characterized by among other things:

- High risk and uncertainty
- Few buyers and sellers
- Ad-hoc usage
- Negotiability in pricing
- High cost
- Regulatory restrictions
- Complex organizational system

In Sweden the construction industry is also somewhat characterized by limited competition (Jagrén, 2005). All these characteristics make it distinctively different from simple products on a market for mass produced goods (Hobday, 1998). Regarding the organizational structure, prior studies on innovation have mainly focused on the firm as an autonomous entity striving to gain a competitive advantage from either external industry sources or from internal resources and capabilities (Gulati et al, 2000). External industry sources can be explained by Porter's five forces (1987) and the internal sources from company specific resources and capabilities (Gulati et al, 2000). However the construction industry is more significantly characterized by a network of relationships that profoundly affect their conduct and performance (Gulati et al 2000).

Firms in those studies usually produce a product that is easily understood by the potential customer and are sold on a market with many sellers and buyers (Hobday, 1998). Companies making complex products differ significantly from mass produced commodity based markets as they, among other things, are more often bureaucratically administrated. In addition it more often has low contestability in contrast to commodity goods and therefore operates in a different way. Additionally complex products or systems are usually customized to fit the buyer's needs and price is negotiated instead of decided directly by markets (Hobday, 1998). It is also common that complex products are made up of subsystems and components (Zhang et al, 2009). An example of this could be an airport where components are the different building blocks that make up a terminal, which in turn

is a subsystem within the airport and has to be coordinated with other sub-systems (e.g. aircrafts, air-traffic-control etc.) for the whole system to work.

Considering these features, firms producing complex products or systems are active in markets that are distinctively different from mass produced commodity goods markets and therefore it is plausible to conclude, as Hobday (1998) and Zhang et al (2009) does, that it is likely that these markets function in a different way. Complex markets, as defined above, like the construction industry studied in this case, have academically been treated more as an anomaly (Hobday, 1998). Considering their importance, it is highly relevant to study this area further.

### **1.3. Purpose**

As stated above, there is a need for firms in the Swedish construction industry to augment efficiency. Increased competition caused by liberalization of the market, increased demands from customers and regulators, and lower government subsidies require this. It is therefore essential to understand what stimulates innovation in the context that construction firms operate in. The Swedish construction market can be considered a complex market where innovation potentially works differently from *classical* innovation theories. It is therefore urgent to gain a better understanding of how innovation works in the Swedish construction industry.

### **1.4. Question formulation**

Which contextual factors are affecting the innovation process in the Swedish construction industry? How does this contextual reality affect the innovation process?

### **1.5. Delimitations**

The area of study in this thesis is which contextual factors are affecting the innovation process in Swedish construction companies. The focus is not on the innovation process itself and the thesis does not try to explain that process but rather how the network and other contextual factors influence innovation. Issues that do influence the innovation process, e.g. individual firms' internal ability to promote and develop innovation, will not be studied in this thesis. The study is also limited to the Swedish construction market where the empirical data has been gathered.

## 1.6. Previous Studies

A study by Widén (2006) shows that traditional innovation theories cannot be applied to the Swedish construction industry because of the context, which increases the relevancy of the thesis. His dissertation (Widén, 2006) shows that the construction sector in Sweden is very complex because it involves many participants in completing a product that is made up of many small parts and the task of coordination in the network makes this very complicated. His findings show that the construction business has a conservative attitude toward new inventions. He also states that the construction sector is complex and therefore limits firm specific innovation. As a result there is a large need to coordinate innovation efforts and resources across an organizational network for innovations to be successful. Widén's (2006) study shows that this is a considerable challenge for companies involved in construction projects and it risks leading to a sub-optimal solution if not performed successfully.

Additionally Widén (2006) asserts that considering the large financial investments that are needed for a construction project, the network is a powerful solution to this resource problem. Because of them it is not necessary to have all the competencies inside of the company providing that the company knows where to obtain and how to integrate them. Widén (2006) argues that a network can be both restrictive on the innovation process and an opportunity to forge new technological and managerial links with other organizations involved in the project.

Furthermore, Widén (2006) states that there is a limitation in most innovation theories in the sense that many of them are focused on business processes rather than project processes, although the latter would have a better application in the construction industry. An improvement in a business process, e.g. on an assembly line at a car factory, can naturally be applied to the next car as all the contextual factors are the same. On the other hand, an improvement in a project process can not necessarily be applied to the next project since there can be many things that are different. His empirical findings show that it is a significant problem for innovation in the construction sector that improvements in one project are not necessarily fully applicable to the next, as every project is unique and itself an innovation.

Previous studies on innovation in the construction sector have also been done by Gann (2000) who tried to explain the low innovation rate that characterizes the sector. According to Gann (2000) the construction industry is characterized by a conservative mindset with a predilection for known and tried solutions. Gann (2000) also argues that there are many reasons for this conservative mindset, where the high investment and the project form are the two main ones. Since most projects require heavy financial investment, using materials that in time show to



be inadequate can be very costly for the firm. The risk of using a new technology or material is therefore too large in relation to the benefit. Gann's (2000) study also shows the same results as Widén's (2006) regarding the transferability of knowledge between projects; the contextual factors can make projects substantially different from one another, making it hard to transfer knowledge from one project to the next one, thus limiting the scope of change and improvements.

Furthermore, Gann (2000) also asserts that competition in the construction industry takes place mainly based on price and project time, and therefore by processes. Gann (2000) emphasizes that considerable product-competencies overlap in the sector has resulted in firms mainly competing on having an efficient process and by that driving down the prices and the time-to-completion.

## 2. Theoretical Framework

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*Innovation in this thesis is studied from a systems perspective, i.e. the innovation process is being explained from contextual point of view. The thesis does not elaborate on how the innovation process at a specific company takes place or how that can be optimized. Therefore the theoretical framework is based on theories regarding innovation in complex products and systems, regulations and networks that are presented in a thematically order. Classical innovation theories that have an internal perspective on innovation are left out. The chapter ends with a summarization of the main points of these theories and it is this framework that makes up the foundation of the later analysis and conclusions.*

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### 2.1. Choice of theories

Based on previous studies by Widén (2006) and Gann (2000) it is our comprehension of the construction industry that it is characterized by a complex organizational structure of multi-firm networks. As the thesis aims to increase the understanding of how contextual factors of the construction industry affect the innovation process, the intention of the theoretical framework is therefore to build an understanding of the context of the construction industry and how it relates to the innovation process and then apply it to reality in order to test its strengths. The thesis has its theoretical foundation in previous studies presented in the introduction and the CoPS theory, which explain how innovation develops in a complex markets and how the contexts affect the process. This is then further elaborated by other network theories with a special focus on interdependence risk, transaction costs, and knowledge sharing. As these aptly describe the coordination problems as well as theories regarding the impact of regulations and standards on innovation, which are very apparent in the construction market.

### 2.2. Perspective on innovation

Innovation in construction can be studied from many different perspectives. Historically, innovation has mainly been studied from either an innovation systems perspective (Widén, 2006) or from the single innovative company. Research on the innovation systems deals with how different companies, government and other institutions relate to one another in the innovation process. It has a contextual perspective on the innovation process while research on the single innovative company studies the specific company's innovation capabilities, strategies etc. (Widén, 2006). This thesis will look at the innovation from an innovation systems perspective; studying the innovation process from a contextual approach.

### 2.3. Innovation Defined

There is no clear definition of innovation as a concept but many varieties exist:

*“Innovation is the process through which firms seek to acquire and build upon their distinctive technological competence, understood as the set of resources a firm possesses and the way in which these are transformed by innovative capabilities”* (Dodgson and Bessant, 1996).

*“It is when an act, as an idea, begins to impact on its environment”* (Atkin, 1999).

*“A technological product innovation is the implementation/commercialization of a product with improved characteristics such as to deliver objectively new or improved services to the customer. A technological process innovation is the implementation/adoption of new a or significantly improved production or delivery methods. It may involve changes in equipment, human resources, working methods or a combination of these.”* OECD, 1997

Similarities for all of these definitions are that they are focusing on improvements or change. Additionally, according to previous studies by Widén (2006), an innovation could also be putting together old technologies or materials in a new way. Thus every construction project, since a new construction project has its unique requirements depending on the demands etc., is an innovation. Based on these previous understandings of innovation this thesis will have a broad definition encompassing any kind of improvement that the firm makes regarding process, products, business models etc. that lead to a better performance or a better offering in the market.

### 2.4. Innovation and Complex Products and Systems

Complex products and systems (CoPS) can generally be defined as high-tech, complex business to business (some exceptions) capital goods that are made up by interconnected and customized parts (Hobday, 1998). Though not all of the construction industry can be considered to be CoPS, mass-produced housing with old technology might not be CoPS, whereas green building can be. Although the complexity of the project can also be related to a process complexity and does not only include complicated products. When studying innovation in CoPS it is relevant to take the perspective of the project or the organizational network instead of the specific firms, because many of the inherent problems of CoPS's complexity are due to its many participants.

Since CoPS projects are complex, the innovation processes within them are also very complicated. This is especially true considering that they require large up front investments in fixed assets and that there is a large uncertainty, and therefore risk, about the success of innovation. However, as Hobday (1998) points out, it is important to emphasize that complexity, risk, and other critical factors are a matter of degree and are not necessarily high in all CoPS projects.

As a result of its complex nature, innovation in CoPS is almost always incremental and slow, unless substantial external pressure is put on the firms in the network. Nevertheless innovation at the *firm level* might be disruptive, which can cause problems on the project level as coordination is complicated by a very large number of alternative design paths. The challenge of coordinating all participants so that they work towards a specific goal limits the innovation effort (Hobday, 1998)

Another factor in CoPS is the intensity of *customer involvement* and the final users' understanding of the product. Getting the customer to understand the final result and being able to incorporate their ideas into the process is a vital skill. Hobday (2000) points out that the feedback process differs significantly from classical markets in the sense that firms get feedback from customers during the process of building instead of getting it after and then adapting the product. The implication of this is that the innovation process and the diffusion process, which are traditionally separated, overlap considerably.

Furthermore, process-learning from one product generation to another can be haphazard (Hobday, 2000) due to the difficulties in transferring knowledge from one project to another, changing user needs, and the customization of component inputs. This view is confirmed by Widén (2006), who emphasizes that even though most construction projects are successful, the spread of new insights stop at the end of the project, thus hindering the optimal innovation process.

In the classical model of innovation, it is assumed that firms compete in a technology race while consumers decide which products will be successful. However, this is not applicable in CoPS because the former build on the premise of markets for mass produced goods with a shorter life cycle. However, technological races can be apparent inside of the potential organizational network (Hobday, 1998). For example a supplier market may have similar characteristics as a *normal* market for mass produced goods. Differences to this perspective are of course a matter of degree, but a building or a building-complex represents a huge

investments and its operational life cycle stretches over decades. Additionally the innovation process can take place a long time after the product is *delivered* and it usually requires a coordinated effort from many suppliers (Hobday, 1998).

Since a CoPS product tends to be made up of sub-systems and components, the degree of hierarchy is greater than most *simple* products (Hobday, 1998), which adds to the degree of complexity and the hardship of coordinating the process. An example of a high hierarchy product can be an airport, which is made of terminals, air-control systems, aircraft etc. and that in turn is made up of other things. This is in stark contrast to a chocolate bar that is only made up of a few ingredients. Hobday continues (1998) by arguing that the life-cycle of a CoPS product tends to not follow the life-cycle of a conventional product. Instead it tends to exhibit emergent and unpredictable properties; the result of innovation and changes of product is hard to predict at the initial stage, especially when the innovation takes place in one part of the big process. Due to this the latter stages of the life-cycle are usually not reached where competitive advantage and the rewards of innovation are centered (Teece, 1986)

Other characteristics of CoPS projects are that they tend to be in networks in a market that is duopolistic, highly institutionalized, and involve negotiation over price. Furthermore, they usually have low contestability and high regulation, which according to Hobday (1998) affects the industry innovation in its direction and speed. This concept is further developing in the section about *regulations and standards*.

### **Project based organization**

According to Hobday (2000) firms producing CoPS usually organizes their structures and strategies around a project that cuts across conventional industry boundaries. Hobday (2000) argues that the project is the main platform for coordination and that this temporary organizational form works as a device that enables different types of supplier firms, users, regulators, and professional bodies to agree on the details of the development and production. The resources of the participants need to be combined and coordinated over time. This coordination problem can, in larger construction projects, require substantial technological, managerial, and financial ingenuity for the project to be efficient.

Considering the project strives to meet the specific need of one customer, the project management task can be quite different from the classical mass-production task. Hobday (2000) emphasizes that one of the most important tasks of the project managers is to coordinate the innovation of many participants and make them aim for one common goal.

Furthermore, the customer will have a prominent role in the innovation process as it is the customer's that are to be fulfilled. As a result, the ability to deal with feedback from consumers is an important asset in a project based firm (Morris, 1994).

In summary, the CoPS theory shows that, if the construction sector works as a market for complex products and systems, some or all of the following characteristics will be apparent:

- Customers have a substantial impact on innovation
- Customers are most often other businesses
- Innovation is mostly incremental
- High risk and uncertainty limit innovation
- Complex coordination
- Project organization
- Institutionalized markets

## **2.5. Regulations and standards**

The construction sector is characterized by both many regulations and the presence of numerous standards. According to Tao et al (2010), regulations have a profound impact on both the direction and the speed of innovation in the market. Tao et al. (2010) explains that the complex market usually stands for incremental innovation whereas revolutionary changes are supported by regulations. Disruptive innovation can also happen in complex markets but they are far less common. This is because revolutionary changes typically have long term benefits for the company, or even for society, and it is therefore not as appealing of an option for a company trying to maximize short term shareholder value.

Tao et. al. (2010) argues that more stringent legislation provides an incentive for collaboration and technological advancement. Without it there is a risk that incumbent firms will try to block new innovation from newcomers. However, with the legislation new technologies are pushed forward. The incentive for collaboration leads to an increased rate of diffusion of new innovation because this new technology becomes the cost of entry to the entire market instead of a desired quality that some consumers demand (Tao et al., 2010). Therefore, it is vital for all companies to acquire the technology. Larger firms are therefore likely to form alliances with smaller firms, which have developed top of the line technology in order to integrate it into their processes. An example that is applicable to this study is as follows: if legislators set

a new standard for energy efficiency in construction, companies that do not have the skills to reach that standard at this moment do everything that they can to acquire those skills as not doing so would disqualify them from competing in the marketplace.

The process can be summarized in the following way:

- Legislator sets a new standard.
- This leads to a standards race in the marketplace as all firms try new technologies in an effort to reach the new standards.
- The standards race pressure firms to form alliances with other firms as it is quite unlikely that your own firm will be the frontrunner in developing the new technology. This leads to increased diffusion of innovation.

A standard refers to a general technological standard. In the case of the thesis Green Building is one which requires 25% better energy efficiency than a set norm.

Certifications can play a similar role even though the pressure on innovation diffusion will not be as strong as that which is exerted by standards. When it comes to markets with products that have a big impact on the environment, it is common that both of these legislative forces are present (Tao et al, 2010).

There are two important points to make when it comes to regulations and certifications. Firstly, they lead to directed innovation (some innovations are favored over others) and secondly, they lead to a race for a new technology standard. The race for new standards of technology has clear path dependencies (Schilling, 1999) where the technology chosen depends both on previous events and chance, making it difficult to discern which technology will dominate the market. According to Schilling (1999), there are substantial learning curve effects when it comes to a new dominant technology. For example technologies released into the market earlier than others usually keep their head start as it get further improved and developed by users. Considering that the standard race has these aforementioned features Schilling emphasizes (1999) what Tao et al (2010) also discusses which is that forming alliances and/ or networks with other firms can increase the speed of adoption and access to new technologies.

## 2.6. Network

Analyzing the innovation process in a network requires a solid understanding of network organization. Gulati et. al (2000) stresses the need for a more integrated view on how value is created in an industry context. As mentioned in the background, Porter's Value Chain perspective is insufficient for new emerging strategy theories. Rather, according to Gulati et. al. (2000), one should approach the field of network theory by considering 5 key areas:

- Industry structure
- Positioning within in an industry
- Inimitable firm resources and capabilities
- Contracting and coordination costs
- Dynamic network constraints and benefits

Perspective on *Industry structure* is making a transition toward viewing companies as dependent on relationships, status, and rules in determining company behavior within the industry. The value chain and the innovation process have traditionally been studied with the single firm as the central player (Gulati et al, 2000), where value is added from left to right by a two dimensional value chain. However, in a more complex market, it is necessary to look at value creation and innovation from a network perspective. In the industry, *strategic positioning* and grouping can be valuable for firms, wherein firms fend off competitors by forming alliances with other firms within the network. This strategy is comparable to what is discussed in step 3 in the previous chapter: the pressure to form alliances with other actors in the market. Hence, innovation may be dependent on how this grouping is organized. As the RBV theory (Barney, 1991) suggests, the firm should differentiate with the intention of being inimitable. Taking this idea one step further, the network as a whole should possess these features. According to Gulati et al. (2000), the network structure requires that innovation and value creation must be properly coordinated throughout the network of collaborating firms. Gulati et al. (2000) argues that in order for the innovation process to be optimal, it is vital that all the collaborating companies work together toward a common goal. If firms only follow their own goals, which maximize their own short profit, rather than working toward the general goal of the network they risk the creation of a sub-optimal network. The ability to utilize others within the industry is an important factor, because building trust between firms brings unique value to the network one is operating in. This is tied to *network dynamics*, which are far more complex than the stand-alone company. Furthermore, a successful



outcome depends on exogenous pressure from actors outside the network and endogenous ties within the network (Gulati et. al., 2000). As outlined, these characteristics of a network have important implications regarding how firms within the network interact and thus how innovation diffuses

### **Transaction costs**

Whereas Gulati et. al. discusses (2000) what defines a network, the implications of innovation are outlined in another theory, developed by Williamson (1985), which covers the transaction costs of firm interaction. Williamson argues that there are three dimensions to transaction costs: resource specificity, transaction uncertainty and transaction frequency. Resource specificity represents the following idea: the more narrow functionality a resource has, the higher the transaction costs. In the construction industry, large investments are a driving force of resource organization and represent a significant contribution to the size of the network. Transaction uncertainty is a reflection of the supplier's capacity to deliver what the buyer requires. By building trust among the participants in the network, uncertainty can be diminished, resulting in a more efficient network. This results in a competitive advantage for participating firms, because an efficient network usually coincides with lower transaction costs. By increasing transaction frequency in the network, a more efficient market structure is created than if, for example, the construction company does everything by itself. The Theory of the Firm and its application in a network context is therefore relevant. According to Jarillo (1988), transaction cost is significant factor when one is analyzing network interactions. In order for innovation to diffuse within the network, transaction costs should be lowered. The choice between outsourcing and organizing internally demonstrates how transaction costs can be utilized to help explain process innovation, wherein internal organization is represented by internal cost, IC, and outsourcing is represented by external cost plus transaction costs,  $EC + TC$ . Consequently, low transaction costs facilitate the diffusion of technology for firms involved in the network.

### **Coordinating the network**

The discussion of how innovation is affected by the context of the industry is heavily influenced by the network's web of participants. Accurately assessing the risk of this *interdependence* among participants can be crucial for success in the industry (Adner, 2006). Interdependence risk explains the need for other company's projects to succeed before one's own innovations have an opportunity to flourish. Since some innovations are merely parts of a

larger project, network participants should assess the risk of releasing new innovations in such an interdependent market. This awareness is vital for an organization in the value chain, because the greater the complexity and quantity of relations, the greater the risk and uncertainty experienced by the firm; being dependent on others implies coordination risks in the network. Moreover, it is important to assess when a competing firm within the web should adopt a solution before one's own firm takes the same step. If a new solution is to be integrated into a building process, its implementation is dependent on how others react and accommodate the innovation. All of these risks play an important role in determining how the network is coordinated and how the relationships within the network are built. Therefore, risk has the capacity to prevent a fully integrated and economically efficient network.

The construction industry is usually organized in strategic networks. According to Gulati (2000), it is characterized by horizontal and vertical relationships with other organizations. It is important to consider how generative the network is, meaning to what degree it elicits exchanges wherein the novelty and applicability of innovations are balanced so as to generate a desirable outcome. Eneroth and Malm (2001) argue that the strategic network can be taken one step further, becoming a knowledge web. This thesis will focus on *knowledge-sharing*, which affects how generative a network is. The starting point in Eneroth and Malm (2001) is that this dimension describes the interaction between companies in the industry as a whole. However, the usage of knowledge webs in this paper focus on the interaction and the network conduct between the construction company, e.g. NCC, and their suppliers. The assessment is that the theories can be applied analogous.

The exchange of ideas within the network also influences innovation. As articulated earlier, the construction company is at the center of the web and acts as the mapmaker by sharing visions for the industry. Other participants entwined in the web have the opportunity to adopt new ideas from the mapmaker and share the vision of the web as a whole. Exporting and importing new ways of thinking and innovations is a cornerstone of firm alignment and coordination in the network.

## 2.7. Summary of Theoretical Findings: Preliminary Framework

According to the above theories, innovation in the construction industry can be explained from a contextual standpoint by the following:

- **Regulations and Standards** – Both Hobday's (1998) and Tao et al.'s (2009) research shows that regulations and standards put significant pressure on the direction and speed of innovation. Tao et al (2009) stresses that the unregulated market is, *ceteris paribus*, characterized by an incremental process without direction where innovation takes place in a variety of directions. Their findings show that, if a governmental agency regulates an industry, they create a new cost of entry that stimulates innovation and the diffusion of innovation up to the standards demanded by legislation (Tao et al., 2009; Hobday, 1998).
- **Complex Processes** – The complexity of the organizational or network structure makes it a challenge to coordinate efforts, which can slow the innovation process (Gulati, 2000; Hobday, 2000). Companies tend to work together on most projects and the success of one innovation, at least major ones, depends on others in the network (Adner, 2006). This interdependency results in a need to share ideas for all parties involved (Eneroth and Malm, 2001). According to Hobday (1998), complex projects can require substantial technological, managerial, and financial ingenuity in order to successfully coordinate all the firms involved and get them to aim for a common goal. Therefore, it can be argued that the complex organizational form limits the scope of innovation.
- **High Investment Risk** – Hobday (1998) asserts that investment in complex products and systems, of which construction may be one, requires large upfront capital investments. Consequently, the risk of investing in new materials is very large in comparison to the potential benefit. Hobday (1998) stresses that in markets where companies are facing this reality, participants act conservatively with regard to new materials and investments.
- **High Uncertainty** – According to Hobday (1998), the complexity of the products and processes and the ambiguity of consumer demand make it difficult to understand the impact of a potential innovation. Hobday (1998) asserts that the life-cycle of a CoPS product tends to not follow the life-cycle of a conventional product, as CoPS products tend to exhibit emergent and unpredictable properties. For example, the result of

innovation and changes of products and processes are hard to predict at the initial stage, especially when an innovation is only a single component in a larger process. This opacity with respect to the end result of implementing new projects is likely to slow the innovation process.

- User Driven – A main characteristic of the innovation process, according to Hobday's (1998) research, is that the buyer (e.g. a real estate firm) has a substantial power over the specifics of the product and therefore the innovation process. Therefore, as Hobday's (1998) findings show, the buyer in a market with complex products and systems, such as the construction industry, usually has extensive knowledge and experience about the subject, and applies this knowledge by setting the requirements for the new product, thereby affecting the innovation process. For example, a real estate firm tries to understand what the market will want in the future and then uses its technical expertise to affect the construction companies in the desired direction.
- Path Dependencies – According to Shilling (1999), there are two kinds of path dependencies that may be relevant to this study. Firstly, considering the alternative investment paths that are available to firms, companies that focus one thing, e.g. low-cost building, can lose, relative to competitors, competence in other areas, e.g. green building. The history of the firm's investment decisions can therefore have an impact of their future innovation efforts.

Secondly, there exist several potential paths for companies to explore so as to reach the goals of the industry. With several solutions to the same problem, there will be one that is better than the others. According the theory, it is plausible that this will result in a race for a dominant standard in the industry. Both of these factors make it very important for companies to keep track of what competitors are doing.

- Trust – As outlined by Gulati et. al (2000), trust is one of the main requirements for a network if it is to be effectively cohesive and amount to a level of productivity greater than the sum of its parts. The network nature of the industry and the fact that many companies need to be coordinated to reach a common goal means that trust between the participants for each project is essential. Moreover, trust building in the industry is correlated with lower transaction costs, because it thwarts the degree of uncertainty (Williamson, 1985).

- Unique Projects – Every project is uniquely tailored to the demands of the customer, which, according to Widén (2006), is in itself an innovation. Both Hobday (1998; 2000) and Widén (2006) stress that the uniqueness of each project makes it more challenging to transfer knowledge from one project to another because of different contexts, thus negatively affecting the efficacy of innovations.

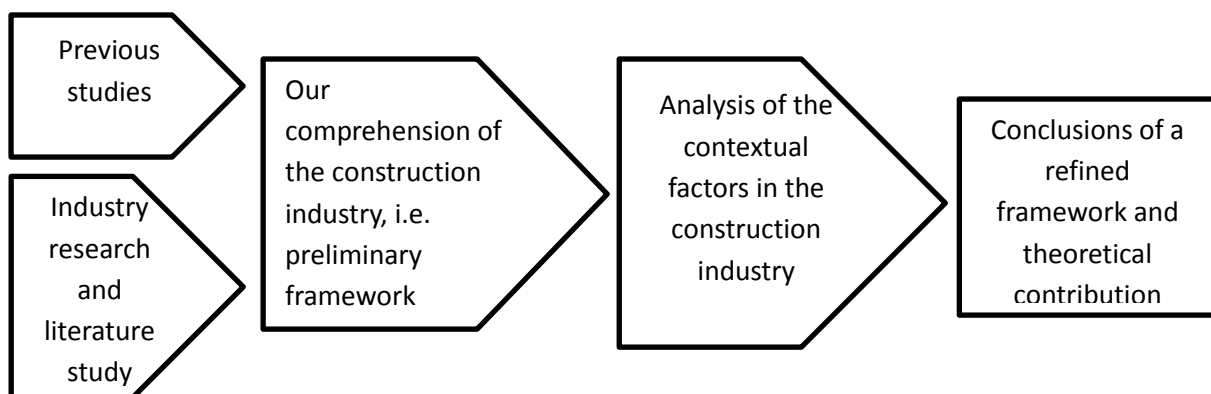
### 3. Method

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*Given the purpose for this thesis a qualitative and a combination of an inductive and deductive approach has been selected. A case study is motivated as the best method to reach the desired results. Interviews with key players in the construction industry are the foundation of the research, which has been carried out with NCC, Skanska Construction, Skanska Green Building, an Architect at Meiby Ark & Design, MKB Fastighets AB and Axis Communications.*

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*Introduction: The research field about networks and how innovation emerging is not converging to rigid and fully developed theories. As shown below the factors outlined in section 2.7 has its origin in industry research and previous studies. As stated, the theories used in this thesis are a compilation of where the field is today and integrated as one distinctive framework. The factors will then be tested against reality to give an answer to our purpose but also contribute to the main theories used.*



#### 3.1. The construction industry

As stated before this thesis is studying how innovation takes place in the construction sector. The industry is characterized by having a complex multi-firm context that makes innovation take place in a way that is potentially different from normal innovation theories which makes it an interesting case.

#### 3.2. Green Building

The subject of analysis for this thesis is the innovation process in the construction sector. To get objective information about this and to not make it too theoretical the data-gathering will

be centered on a concrete innovation. Green building is chosen because it is a modern result of the innovation process and is therefore highly relevant to study how the contemporary innovation process works.

The concept Green Building refers to sustainable buildings that maximize energy efficiency (Construction Digital, 2010). According to Construction Digital (2010) the firms work with the green building concept not only because it is the *right thing* to do but also, or perhaps mostly, because it is good for business. Energy usage in buildings is of great cost (Skanska Green Book, 2010) both to companies, the buyers, and to the environment. By offering energy efficient buildings the customers of construction firms can cut their utility costs significantly *and* increase their goodwill by marketing that they take responsibility for the environment. The demand for sustainability in construction and lower energy usage is high both among customers and regulator so in that aspect green building is an interesting innovation. According to NCC:s website (2010) a *green building* must have energy usage that is at least 25% underneath the industry norm. On top of this most companies have their own standards and requirements that should be seen as indicators of an increased performance of their construction.

An example of how a company concretely works with green building can be taken from Skanska's green book (2010) and Construction Digital (2010) that describes the very same phenomenon. They state that to achieve green building status firms use modern technology to create an ecosystem that has some or preferably all of these qualities:

1. An infrastructure that promotes walking and biking
2. Renewable on and off site energy supply
3. Waste recycling
4. Green Roofs
5. Rainwater Harvesting and Water Recycling
6. Regional Materials and Resources
7. Healthy indoor air quality

Alternatively it can also be an old building that has been modernized by making it energy efficient.

### **3.3. Abductive inception**

Drawing parallels to Bryman and Bell (2003) the task for this paper is to generate a contribution to the research field of how innovation works in the construction industry. A matter of great importance is to select what theories there are today; to build a framework for how the data in fact will be gathered. From the theories selected a more specific framework will be compiled with factors that are likely to explain the purpose, thus there are deductive elements incorporated (Bryman and Bell, 2003).

### **3.4. A case study**

This thesis is focusing on the innovation phenomena in the construction industry and to describe how contextual factors affect the process. According to Yin (1994) a case study is a preferred strategy when “how” or “why” questions are being posed, when the investigator has little control over events, and when the focus is on a contemporary as opposed to a historical phenomenon. Therefore it is clear that a case study would be appropriate to broaden the knowledge of how innovation in the industry works.

This thesis employs a qualitative approach, since the purpose is to gain a deeper understanding of innovation in the construction industry. Another approach could be a closed ended questionnaire where the interviewee is not given any space to show other aspects to the matter; hence important dimensions could be left out. The phenomenon is studied in a real-life context and thus the boundaries between phenomenon and context is not clearly evident (Backman, 1998). This is in line with what Bryman and Bell (2003) stresses with a similar motivation. Here it is important to point out that the theoretical framework is aiming for the contextual conditions in the construction industry. Whether the findings can be applied to a different context is an empirical question and will be discussed further in the conclusions. A case study is also motivated by the complex nature of how an industry is emerging; a view settled in the introduction by among others the CoPS theory. Furthermore, since a case study is chosen two questions appear. Firstly why is not all companies in the industry taken into the study, and secondly, obviously there are other networks in other industries that also could be taken into consideration? The obvious answer is that it would be too time consuming and unfocused for a master thesis. Furthermore, since the



matter this thesis is dealing with is rather complex a more focused approach is conducted with fewer observations. Hence, the assessment is that a statistical study would not be sufficient for the needs in this thesis.

### **Unit of analysis**

As mentioned before a range of companies that operates in the construction industry will be appointed to test the theoretical framework. An important note to make is that these companies are selected to get an overview of the industry and all participants of the network. Considering that the construction industry is organized in networks where the participants potentially have different aspects on the innovation process it is important for this study to focus on getting as many perspectives as possible. In the dilemma between aspect rich and observation rich research, aspect rich is to prefer in this case.

An alternative would be to gather data from several people inside of one company. However since the thesis is studying how the context affects the innovation process it would not be as good to only study one company's perception of their context as this risk being biased.

### **3.5. Gathering and processing of data**

The data is gathered from two sources; desktop research and interviews. The desktop part is motivated by that it is a suitable starting point to enable a better understanding for the subject but also to interpret in what direction the industry is striving. The main source for the desktop research is articles covering the industry, the selected companies for the study and green building. Since the study is focusing on a phenomenon in transition, it is stressed that the articles must be up to date. This also provides a healthy iterative process between theory and the empirical findings as mentioned above (Bryman & Bell, 2003).

The bridge between theory and the data gathering process is the questionnaire. When this guide was compiled it was important not to be too specific and vice versa, as recommended in a semi-structured guide. Furthermore it was also important to translate the theories into something approachable for the interviewee by not stating too "theoretical" questions. Referring to the green-building concept was also a way for the interviewee to be easier orientated with innovation in the construction industry.

The interviews strive to get a deeper understanding about how the companies themselves look at diffusion of innovation in the industry, what do they prioritize? Here, an industry perspective is taken, also put as studying the nodes between the parties within the network.

The possibility of parties having different views and experiences of the subject is something that is considered as strength for the thesis, especially when there is an indistinctive line between context and phenomenon is present.

The interviews will be semi-structured. This approach is recommended by Bryman & Bell (2003) when the researcher for example has a clear focus, multiple-case-study ensuring comparability between cases in the study. These features and the overall flexibility with semi-structured interviews are sought after and hence chosen as the interview form. The questions will be partly open-ended and therefore giving the interviewee a possibility to fill in his or hers perception on the subject. However, the interview guide will be sprung out of the theories presented. This match is stressed as important since the iterative process discussed earlier will be heavily dependent on how the data and especially how the interview guide is designed (see appendix). The interviews are recorded and suitable quotations are picked to designate vigorous points. The persons selected for the study is basically ones' with an insight in how innovation is conducted. The guidance and selection fall upon respective company, which is a natural procedure since they possess the knowledge about the key-people for the purpose.

### **3.6. Validity and reliability**

Validity is considered to consist of internal, i.e. casual linkages between variables used, and external validity i.e. generalizability. (Bryman and Bell, 2003).

The internal reliability can also be interpreted as relevance (Glaser, 1978). In short it describes how relevant the findings are to existing theories; this is used in the analysis section.

The results will take its starting point in how innovation is working in an industry with complex organizational conditions and thus it is hard to generalize over various industries but it is not impossible. Since one can identify the same characteristics and contextual conditions elsewhere and intuitively draw the conclusion that the findings can be used there too. On the other hand it is hard to find an industry with the same contextual conditions and therefore the logic presented in this thesis can be hard to generalize to other industries.

Another limitation to the generalizations is that this thesis picked out green building as a concept to make it easier to gather data about the subject which results in that studying another innovation may lead to different conclusions. This discussion draws parallels to the external validity of the thesis (Bryman and Bell, 2003) and here it is suggested that the setting that the construction industry is in now may change over time thus replicating the study with the same results can potentially be hard, hence it is a sign of the qualitative nature of the subject.

It should also be stressed that the factors developed and studied in this thesis are not necessarily interdependent of each other. For example, regulation in the industry does not affect coordination; still the interplay between factors may construct the complex and unique features that characterize the industry, which is motivated by a case study. To penetrate the subject in a wider way it is necessary to study the purpose in other industries but the view here is that it is up to other conduct such studies.

Bryman and Bell (2003) argues that reliability is hard to establish in a qualitative report but an attempt will be made. The question is whether the results can be replicated and there are obvious problems to the thesis. Reminding the reader about the purpose, hence there is an inherent contradiction that the results presented can be replicated since the factors facilitating innovation in the construction industry can change over time. However there are different approaches to increase reliability. They will not be examined in a wider meaning in this thesis.

### **3.7. Analysis**

As outlined in the aim for this study, network theory and the innovation process is in focus. Further on, using the relevant findings in the data according to a given predetermined methodology, there has to be a set of rules how this is conducted. The pattern-matching method is used. (Yin, 1994) It consists of three steps; firstly, where there is a match. Secondly, where theory can be developed and thirdly, where theory is not applicable to the specific case. This pattern matching is used to develop a final framework concluded from a preliminary framework based on the theories chosen and empirical results. This view corresponds well with the iterative procedure mentioned before.

There is a disadvantage with this proposed method, the reality is studied from the initial framework and hence will affect the empirical results from this perspective. This problem is mainly dealt with in two ways; the semi-structured interview method will enhance the space for the interviewee to come up with own ideas of what these contextual factors might be. Secondly the interview begins with general questions and is finished with a question explicitly asking for the interviewee to contribute in their own way.

### **3.8 Empirical presentation**

The empirical results are presented in a thematically as in the preliminary framework so that the pattern matching method later could be conducted. The text is presented in a narrative manner; hence, the reader could easily follow what has been said about each factor. The quotes are highlighting what has been regarded as important. This gives the reader an opportunity to be critical to the conclusions and analysis made later.

## 4. Empirical Findings

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*The empirical findings are presented thematically. Under each of the preliminary factors empirical evidence that either confirms or denies the initial findings are listed. Statements from the interview that are not connected to any of the preliminary findings are organized in the end.*

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### 4.1. Regulations and Standards

According to the Project Coordination at Skanskas Norra Hamnen construction in Malmö (Hall, 2010) the development towards more environmentally friendly building is pushed forward both directly by increasing demands from the customers and indirectly by stricter standards from within the company. The Project Coordinator explains that Skanska's standards for green building is stricter than the governmental regulations that construction firms are required to follow according to BBR (Boverkets Byggregler) but says that, "*since this may change over time and there is a clear direction towards stricter regulations it still puts a significant pressure of the industry*". He further explains that there is almost no doubt that this will be the future; "*the construction industry has historically been, and is still, very influenced by regulators and considering that a greener orientation of society is an outspoken goal we will no doubt be the target of increased stringency in regulations*" (Hall, 2010).

The Construction Manager of MKB (Persson, 2010) agrees with this view and argues that the industry is strongly affected by regulations. He says that Boverkets Byggregler, BBR, is the foundation of the requirements that the industry have when building a new building and then they put their own standards on top of that. However he further explains that when it comes to environmentally friendly building the regulations are far behind where the industry is.

He also says that for them as a public company the law of public purchase (lagen of offentlig upphandling) also has a significant impact on their behavior. He is positive to this type of legislation and further explains that even though it requires some extra work from their side it puts pressure on them to accept the best offer instead of choosing the same company as last time, which according to him, is better for the public owners.

The Project Coordinator at Skanska (Hall, 2010) explains that the reason the market is so far ahead is that the present requirement for green building are relatively low, only that the energy usage is 25% below the industry standard, but according to him this will probably increase as new innovations increase what is feasible. Today green business projects are mainly made up of already existent technology that is put together in a new way.

Skanska's Project Manager for their Green Building (Hedve, 2010) concept concur to the idea that regulations heavily affect the industry. He explains that without incentives and stricter regulations we would not see today's rapid change in the business. As BBR (Boverkets Byggregler) gets stricter the industry need to improve their standards. The Project Manager of Green Building (Hedve, 2010) agrees with the picture that market is ahead of the legislation but explains that most participants in the market expect the regulation to become stricter in the future which puts a pressure in the industry.

He exemplifies with the UK, as a country that is ahead of Sweden and where legislators have implemented a successful system that promote a greener building. The Project Manager (2011) explains that in the British system everyone that is above the average emission have to pay higher taxes while companies with lower emissions pay lower. He further explains that Swedish authorities are trying to construct a similar system; a system that promotes a greener building by financial incentives, but the one that is in place right now is not working that well. The Project Manager (Hedve, 2011) argues that in the present system companies apply for money after a project is paid for without any guarantee to get money for their efforts. He says that this leads to that constructions firms view the government money as *bonus money* that does not change their behavior.

The Regional Manager of NCC (Hedin, 2010) also agrees with the picture that regulations affect the industry substantially and further explains how it guides innovation. He exemplifies it with an explanation of the deregulation process in Sweden. Before the deregulation of the construction industry state authorities controlled a large share of what and how things should be built. The industry was heavily dependent and in detail restrained by government subsidies. When deregulation came subsidizes disappeared but things like the "*rent control*" system were still there, where to public real estate company negotiates rents with the tenants union. Considering that the price of land is the same regardless of what kind of house the construction firm is building it has led to that it is much more profitable for them to build higher scale houses for people who have money than rentals.

NCC:s Regional Manager (Hedin, 2010) also asserts that regulation is a strong driving force behind the development but he explains that he believe that the regulation that is putting more substantial pressure on the industry is the EU regulations that will be set in place in 2019 and 2020 and have, at least from the point of view of the industry today, high demands. The BBR (Boverket Byggregler) is today so far behind that market so it is not adding any extra pressure.

## 4.2. User driven innovation

According to the Project Coordinator at Skanska (Hall, 2010) the clients are the strongest force behind the development. He says that "*All large clients know exactly what they want*". An example that he mentions is Skanska's construction project in Norra Hamnen, Malmö where the city of Malmö is the client. He explains further that the city of Malmö has many years of experience in construction and they know how the industry works; they know what is technically and economically feasible. Because of this they can give very exact instructions of how they want everything. They also have their own inspectors that come out to the construction site and make sure that everything goes according to their plan. The Project Coordinator asserts that there is a substantial trend towards more greener building (Hall, 2010) and that different clients get inspiration from each other for what is technically and economically plausible. He explains that large projects that use new technology tend to push the standard forward and exemplifies with the Citytunneln in Malmö (Malmö subway) which has used modern technology to mitigate the environmental impact of the construction. According to the Project Coordinator (Hall, 2010) it has been very successful and an inspiration to future buyers and contractors.

On the other hand, the Project Coordinator says (Hall, 2010), with smaller and inexperienced clients the reality might be the opposite. Then Skanska needs to show the customer what is feasible and what they can get for their money. However the Project Coordinator at Skanska (Hall, 2010) is adamant about the difference between private customers and company customers when it comes to pushing the development of green building forward. He explains that private customers are usually very limited by financial means and therefore more strongly prioritize the economic aspects while corporate customers have other variables to take into account as well, such as brand value. However, NCC's regional manager (Hedin, 2010) asserts that they have noticed that even private customers are starting to attach more value to a greener home, which in the case of user-based innovation will be reflected in higher demands by the real estate firm.

NCC's Regional Manager (Hedin, 2010) further elaborates the view about the impact of the customer by saying that customers have a large influence on how the new building is designed and what it should symbolize. According to the Regional Manager (Hedin, 2010) the way to do things in the industry is putting together a team with all the parties involved and disclose all information, e.g. costs, design. When this is done, NCC takes over and executes the outline of the project specifics.

The Construction Manager of MKB (Persson, 2010) agree with the general view that buyers have a strong power of the project and indirectly over innovation efforts, he says that they have very large opportunities to put a pressure on the construction companies. They have a long experience and they know what is feasible. He explains that they have a systematic way of dealing with what they require of a new building. The foundation of their requirements is, as stated earlier, made up of what is required by the law, and then on top of that they have their own standards and their own demands from previous successful constructions and lastly new ideas from inside the organization or from inspiration from others. Their demands are ranging from general to very specific reaching from where the mirror should be in the elevator to what type of energy usage that the building should have (MKB Funktionskrav Nyproduktion, 2010)

The Architect at Meiby Ark and Design (Meiby, 2010) explains that building projects tend to be highly customized to the customer needs and therefore they have a large influence on the final product. The Architect (Meiby, 2010) stresses that their “architectural ambitions” trumps building technology which strengthen the notion, outlined in the risk section, that there are some risk taking in favor for these ambitions. According The Architect (Meiby, 2010) this is entwined with the deregulation of the market which has resulted in that customers have taken the lead as the main influence on the building process.

The A&E Program Manager at Axis Communications (Eriksson, 2010) agrees with the view that the buyer has substantial power over the production process and indirectly over the innovation process. He states that an effective way of affecting the industry in some direction is to turn to the end-customer, trying to convince them about a solution, through this putting pressure on the architects and construction companies to develop what the customer demands. A method they use is to educate the customer about the advantages with their solutions. This is in contrast to not turning to the construction company trying to make them interested of their products.

### **4.3. Risk and Uncertainty**

The empirical finding can be generalized into two basic categories: internal and external risk.

#### **Internal risk**

The Project Coordinator (Hall, 2010) and the Regional Manager at NCC (Hedin, 2010) says that risks and uncertainty are limited in the respect that the construction business is generally



conservative and use mainly old, tried-out technology and also that most big companies are using the same or similar building methods. The project manager (Hedin, 2010) at NCC emphasizes the material risks. There are a lot of examples where NCC have used materials and solutions that later on have had expensive consequences fallen upon NCC to take care of. These events have thus turned NCC to be more cautious in their rate of adaption. The Regional Manager at NCC (Hedin, 2010) says that “*The acceptance time of a new material is 15 years; we have been wrong too many times in the past*”. Hence, NCC starts off with smaller series and develops only large scale production after it has shown that it will work. According to one of NCC:s Regional Managers (Hedin, 2010) the industry is striving towards doing things smarter in the process instead of coming up with new ideas of materials. The head of the architect firm (Meiby, 2010) contradicts the statement from the process development manager from NCC about the construction industry being cautious when adopting new building solutions. His view is that construction companies are trying out a lot of new solutions without always being certain about the ends. This risk-taking is expensive for the construction firms but also a part of the process of developing new solutions.

Furthermore, the industry could be more cost-effective if a mass-produced effort is undertaken. But the obstacle for the industry here is its dependency on the business cycle, which is uncertain and short-term therefore mass-producing activities, contains a large share of risks.

The Construction Manager (Persson, 2010) emphasize that the most complicated dilemma for them as a real estate company is dealing with the risk and uncertainty of the investments. Hall (2010) supports this view by adding that considering the investments being so large there will always be significant risk in this industry. Considering that MKB usually purchase large projects that require large investments it is very important that everything turns out right from the beginning. For older investments they work with a system of different returns on their *assets*. The Construction Manager (Persson, 2010) explains that buildings that are in an attractive area, e.g. Västra Hamnen, have a low require return, since it is considered to be a *safe* assets, while buildings that are in a less attractive area, e.g. Rosengård, have a higher required return. He explains that for new investment they try to get as many opinions as possible early on in the process to see that they are on the right track.

### **External risks**

Skanska’s external risks consist of the guarantees that they provide to the customer (Hedve, 2010). In order to mitigate these risks each project is scrutinized in a structured process to identify and value the risks involved. The Project Manager continues that if the result of the

risk assessment is that it will be too complicated or too costly to mitigate the risks Skanska will not accept the assignment. For example, the *Augustenborg* project is focused on a greener city life where tenants with the help of large balconies can grow some vegetables, so called *urban growing*, and where there is a strong focus on low energy emissions. Since this is a new project and that there exist an uncertainty about the success of this new project MKB invited potential stakeholder who agrees that it was a good investment. (Persson, 2010)

One risk that the Project Coordinator mentions (Hall, 2010) is the large dependency on suppliers. According to the Project Manager (Hedve, 2010) one way that Skanska mitigates their risks is by getting corresponding guarantees from suppliers. Because Skanska is a dominating player in the market it is usually not a problem for Skanska to export their risk according to the Project Coordinator (Hall, 2010). He says that they are *assembling different systems and making them work together* and in order to do that in a good way they have to have a systemized and supervised construction process. He continues by saying that they have to see *proof* that what they are installing is actually working in the way that it is described; the client cannot be used as a test site. He explains that they do this by inviting in other potential stakeholders (e.g. construction companies, Malmö municipality etc.) to discuss the investment and to see that they are on the right track. On top of this they invite new tenants after about three months to a discussion evening where they talk about what they like and what they do not.

#### 4.4. Path-dependency

According to the Project Coordinator (Hall, 2010) at Skanska, previous innovation efforts are not very important for the direction of future innovation, the project manager at NCC and the architect support this view (Hedin, Meiby, 2010). He says that while it is true, to some degree, that companies have unique competencies and that focusing on for example low cost building might prevent the success of green building, the construction business is different. Furthermore it seems that the main players in the industry has adopted rather quickly to the green building trend, since the competitive advantage in green building is highly valuable. (Hedin, 2010). The project coordinator (Hall, 2010) continues by stating that a construction company combines a unique solution for every project, usually with a traditional technology, to customers that demand very different products. It is therefore necessary to have very broad competencies. He emphasizes that *“for a large construction company that is the market leader one needs to have two different tracks to live up to all potential customers’ demands”*. The Archi-

tect (Meiby, 2010) stresses an interesting explanation which is that the non-complexity of the industry that makes it possible for “*everybody to do everything*”.

On the other hand the Project Coordinator (Hall, 2010) says that some firm specific competencies are evident and he do not think that other companies can come up to Skanska level, in the short run, when it comes to green building.

The Project Coordinator (Hall, 2010) explains further that he thinks that the development of new green technology will be characterized by a standards race. Even though there is a standards race there will be some kind of resistance to it because it will increase the competition (Hedin, 2010). According to him the single actors in the industry are better off with no standard agreed. Additionally the EU directives set up for the industry on what it is supposed to achieve within 10 years, is shaping these standards. On the other hand the project coordinator states (Hall, 2010) that the requirements for green building are very general and therefore there will be many solutions of how to reach them. The Project Manager (Hedin, 2010) complies with this view and ties it to the setbacks for the players with increased competition. It is likely that one solution will be better than others and that it will be something that everyone applies.

#### 4.5. Complex Processes and Network Organization

According to the regional manager at NCC (Hedin, 2010), they are trying to affect their partners so that everybody is striving towards the same goal. With the intention of making this process more effective, NCC is trying to integrate specialists and suppliers. Skanska's Program Manager of their Green Building (Hedin, 2010) concept complies with the idea that they are very dependent on other participants of the network. This is because Skanska (and other construction firms) are selling the combined know-how to professional real estate companies (Hedin, 2010). Still there is a special interest in tending your ideas early on so others may not have a too large influence on the final product. A good example of how NCC is trying to affect their way of thinking into the value chain is the 3D blueprints used at the construction scene. In general, the regional manager (Hedin, 2010) states that they are willing to import new methods but the examples given are parsimonious in the context. The Architect states that *"It is not easy to sell an idea if there is no economic advantage with it"* (Meiby, 2010). Furthermore, he stresses that it is important to be out in the field picking a variety of ideas to develop the projects. The Project Manager of Green Building (2010) agrees with this by saying that new ideas in the network are supported but that they always have focus on the financial reality when it comes to new ideas and emphasize that *"a technical solution is only a solution if there is an economic upside to it"*. Furthermore the Project Manager at Skanska (Hedve, 2010) stresses that he thinks Skanska's ambition is to be decentralized and solving problems in-house can be a bit dangerous and that they need to be in a dialogue with other companies (e.g. consultants, suppliers) to be on the top of what is happening in the market. He continues that there is a slight tendency to a "not-invented-here" attitude which can be very dangerous on a fast developing market.

The actions taken to coordinate a project is to place all the parties in the same room and make them throw their special interests away, making them strive towards a common goal. In order for each project to bear fruit all costs are disclosed, hence preventing a party to sub-optimize their interests. By this means the parties involved can build trust between each other, making the network and the process a valuable competitive edge by the competitors. (Hedin, 2010). "There are too many special interests in the industry" according to NCC's Regional Manager (Hedin, 2010).

Develop, coordinate and integrate the value chain is an important and highly valuable challenge for NCC (Hedin, 2010). The somewhat common expression for this is "we have to fo-

cus on what creates value for the end user”. Looking at the whole value chain NCC sees a variety of ways to create value for the end-user. According to Project Manager of Skanska’s green building concept (Hedve, 2010) there can be a challenge to export ideas between members of the network. Skanska communicates best practice, knowledge and experience between team members through regular meetings, phone calls and emails. He says that through each other’s experiences, successes and failures they are able to accelerate the learning curve. The architect describes another situation (Meiby, 2010). There are always a sub-optimization in the industry blocking an eventual better coordination and value creation for the customer; hence it is important not to narrow your operations down too much and then being too dependent. Consequently, there is not much value to be found in grouping with others since the counterparts are not offering any monetary value back.

Cutting wholesalers that do not create value has been a big task for NCC (Hedin, 2010). The regional manager brings up further problems with the wholesalers and that is that they overcharge for the materials supplied in the industry. An example to counter this is NCC’s integration of their concrete steel operations in-house. The Regional Manager (Hedin, 2010) states that the industry undergoes great pressure from these material wholesalers, what can be considered to be a monopoly market, preventing the construction companies to build cheaper and thus create value for the end-user. Since a great effort is made in the industry to cut costs the wholesalers pose a significant obstacle.

A great step for NCC to be taken is the will to replicate the business models used in the automotive industry, and here NCC is looking at Toyota as the main inspiration. In particular NCC has expressed the intention to integrate their suppliers and tie them closer in the process, creating so called *strategic* suppliers. The proceedings are to manifest that NCC are willing to promise their suppliers a significant volume in exchange for a lasting cooperation and that set ratio of the earnings go into R&D and improvements of their products . The main problem here is to make the parties involved to strive towards a common goal. The project manager states that their suppliers' may not be there yet in their strategic thinking.

Most construction companies possess a unique knowledge within their network (Hedve, 2010). This is part of their competitive advantage and puts an external pressure on the Skanska group to improve their concept, and vice versa.

Furthermore Skanska have a R&D network focusing on various fields, e.g. BIM, Energy Moisture etc. The Project Managers (Hedve, 2010) elaborates by explaining that Skanska own patents in a variety of fields that they believe will be strategic in the future of their business and he says that “developing new concepts, such as Green Business, is very much a part of the innovation process at Skanska” (Hedve, 2010).

According the Skanska’s Green Building Project Manager (2010) trust is vital in the network because it minimize transaction cost and is very important when dealing with knowledge exchange. Trust is major force in the industry, being a dominant factor for who that is getting a job. The architect experiences a pressure on him since if something falters he is the one of the main parties taking the blame.

#### 4.6. Other

Skanska’s Project Manager for the Green Building concept (Hedve, 2010) states that the construction industry and real estate investments in general are often very large scale and have historically had a low willingness to try new solutions. There is, according to him, a predilection for known solutions.

NCCs Regional Manager (Hedin, 2010) describes the construction industry as very complex because that there traditionally have been many stakeholder that has counteracted each other. According to him the industry is stuck in an *old pattern* where everyone is trying to optimize their own profits and not the success of the project which leads to sub-optimization. This is a view that The Architect at Meiby Ark and Design (Meiby, 2010) also concurs with, according to him the construction industry is characterized by everyone trying to sell in their own thing which have a tendency to not lead to an optimal solution for the customer.

Another dominant characteristic is according the NCC:s Regional Manager (Hedin, 2010) that the construction industry in Sweden has oligopolistic tendencies. That is especially apparent in the supplier market where some producers of material have a very dominant position in the marketplace and can therefore charge monopolistic rents.

The Architect (Meiby, 2010) acquiesces with Skanska’s Project Manager for their Green Building concept (2010) that it is a slow industry that prefers already used solutions; it is a mature industry. This has the implication, according to The Architect (Meiby, 2010), that *everyone* can build everything; it is more a matter of having an efficient process. He also mentions that there is a trade-off between greener building and the cost of the project.

The thing that is pushing the construction business forward is to make things cheaper (Hedin, 2010). The average profit margins are about 2-3% and therefore there is a large gain to get from cutting the cost.

## 5. Analysis and Implications

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*In this chapter, a comparison between the theoretical framework and the empirical findings is made. The objective is to evaluate the theoretical framework by comparing how the contextual factors, derived from the theories, correspond to innovation in the construction companies. The chapter also aims to further develop the theoretical framework based on the findings in the study.*

*The analysis is therefore founded on a pattern-matching approach, which is further outlined in the method section. It begins with the results of the study and concludes with the comparison between the theoretical assumptions and the empirical findings.*

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### 5.1. Contextual factors affecting innovation

From both the empirical findings and theory, conclusions about what facilitates innovation in the construction industry can be derived. This study shows that the following contextual factors have a significant effect on the innovation process:

- Regulations – The market is ahead of the regulations, which make them less important, but they still provide guidance regarding where the industry is currently heading. This is because the industry anticipates increased stringency in environmental laws, and these expectations affect decision making within the market.
- Standards, i.e., what defines green-building, are pushing the industry because customers demand greener building and standards help assure customers that a construction company has the necessary skills and experience to deliver the desired project.
- User Driven Innovation – The user is a strong driving force behind the path and strength of the innovation process. As customers are usually big organizations and have previous building experiences, they can usually influence the construction companies to work toward initiatives of their choice.
- High risk and high uncertainty in the industry due to large investments, low margins, and an ambiguity of material performance over the product life-cycle has created a conservative attitude toward new solutions.
- Unique Projects make the transfer of knowledge from one project to another more difficult than it would be for more homogenous endeavors, because contextual factors can be so different.



- Cost – Since technical complexity is not that high in the industry, most companies compete on having a more efficient process than others. Having the most efficient process is therefore *essential* to being successful in the marketplace. Together with low profit margins, this struggle for high productivity puts substantial pressure on increased innovation.
- Complex Processes and Coordination – A construction project is usually developed by a project organization, which is composed of many different participants in the industry. Changes and improvements of the project require coordination of the participants toward the same goal. This level of cooperation has proven to be tough enough to limit the innovation process, because of self-interest and the number of firms involved.

## 5.2. Regulations and Standards

- They affect the industry
- They push the industry forward by creating a new Cost of Entry
- Their impact is weaker than previously assumed

Firstly, it is important to appreciate that the contextual realities from which the theories' conclusions about regulations and standards are taken have shown to be different than the situation that the Swedish construction industry faces today. The theories have studied markets where more stringent regulations are in place. These regulations are on par or ahead of the industry while the Swedish construction industry is significantly ahead of the legislators. Nevertheless, the behavioral implications could be the same or similar. The theories state that markets characterized by heavy regulation tend to exhibit guided innovation patterns and a less incremental innovation process (Tao et al., 2010). They also say that regulations that push the market forward will also lead to a standards race (Schilling, 1999).

The Project Coordinator at Skanska's Norra Hamnen (Hall, 2010) states that "*regulations strongly affect the industry*". He explains that, from a regulatory standpoint, Skanska is more affected by how strict they think legislation will be in the future than what legislation is today. He explains, "...*there is a clear direction towards stricter regulations. It still puts a significant pressure on the industry...*," referring to upcoming reinforcements of BBR and the EU construction law. NCC's Regional Manager says that their processes are affected by legislation but agrees with the previous view that the market is far ahead.

This makes it plausible to conclude that Tao et al.'s (2010) argument that regulation and standards can have profound impact on the innovation process is true, where behavior is guided by expectations of the future as well as other factors.

Tao et al., (2010) asserts that when regulations push an industry forward it *creates a new cost of entry* that is necessary for firms to live up to in order to be able to compete in the market. That this is the case in the construction industry is evident in the empirical findings and supported by interviews at Skanska and NCC (Hall, 2010; Hedve, 2010; Hedin, 2010). This has interesting implications for path dependency in the industry, which is further discussed in the chapter entitled "Path Dependency". However, *the effect of regulations is weaker* than was first assumed by looking at relevant theories. It is reasonable to conclude that this is only because they are not stringent enough. This statement is further supported by Skanska's Project Manager for their Green Building concept (Hedve, 2010). He emphasizes that the industry's behavior is affected by legislation but goes on to clarify that this influence is limited by the inefficiency of legislation. He mentions the British system as more successful because it divides the market in two parts where the more efficient companies get tax deductions and the less efficient ones get punishment taxes.

The business is also characterized by standards. As standards are voluntary, they have a different effect on innovation. They can function as way to connect the firm's differentiation or competence to a standard that the market recognizes. Put differently, as standards represent something that the market acknowledges, they provide an incentive for the firms to improve their processes.

Tao et al, (2010) and Schilling (1999) further explain that regulations and standards will lead to a standards race as companies try different ways to solve the same problems, wherein a dominant technology will emerge later. This type of behavior is supported by statements from both the Project Coordinator (Hall, 2010) and Skanska's Project Manager, as they say that it is a likely development when the market for green building matures that one company will set the standard with a more efficient method of building green. This is further reinforced by NCC:s Regional Manager (Hedin, 2010) who states that it would be very profitable to be the company that sets this standard and that leads the technological innovation.

However, by comparing the empirical reality with the theories it becomes evident that the aspiration to be the technological leader and standard setter does not arise from the regulations and standards that exist but from other forces in the marketplace. This aspiration is

also not consistent with the conclusion that the regulations have limited effects, compared to other factors, because the market is so far ahead.

Overall, it is plausible to conclude that the empirical findings fully support Tao et al.'s, (2010) thesis about how regulations affect the market. Effects appear to be less strong than first anticipated, but this can be explained by the relatively low requirements that the regulations have today. The empirical finding can also demonstrate that expectations in more rigid legislation can have a similar effect, if not as strong, on the innovation process and the diffusion of innovation.

### **5.3. Path Dependency**

- Path dependency is weaker than expected
- Broad competencies are needed
- Green Building pushes the Cost of Entry, which limits path dependency
- Green Building is relatively non-complex

The first part of path-dependency, regarding how historical investment has an effect on future investment and competitive advantage, seems to be weak in the construction industry. This becomes clear as responses from both Skanska and NCC (Hall, 2010; Hedve, 2010; Hedin, 2010) state that path-dependency is not a significant factor in the case of green building. There are several reasons for this. Firstly, the construction industry works differently than a normal market for mass-produced goods in the sense that companies put together unique solutions for every customer (Hobday, 1998). This view is supported by previous studies by Widén (2003), who states that every project is so unique in itself that it can be regarded as an innovation. The Project Coordinator (Hall, 2010) and The Architect (Meiby, 2010) agree with this view, as they explain that, in the construction industry, one needs to have broad competencies in order to tend to all of the demands of a very heterogeneous customer base. This implies that a construction company by to what extent it can specialize and differentiate its products, which may limit path dependency. It also strengthens the notion that the construction industry may not be as complex as was initially assumed because, by comparison, a highly technological complex industry could not be characterized by the epithet that both the Architect (Meiby, 2010) and the Regional Manager at NCC (Hedin, 2010) used for the construction industry, “everybody doing everything”.

Another analysis one can develop from the empirical findings is that the forces of path

dependency are weak in the case of Green Building, as Green Building is becoming a new cost of entry into the market. As stated in the previous chapter, some advancements in the industry are pushed forward by increases in regulations. According to Tao et al. (2000) and Schiller (1999), new regulations with increased governmental demands has the effect of increasing the cost of entry of the industry, which is the minimal requirement that participants must to fulfill so as to compete in the marketplace. From this perspective, a company competing in the construction industry *has* to invest in improving their environmental building, because it is required by the regulations; they have no alternative and are therefore not abandoning other potential opportunities. This type of analysis can also be made from the perspective of user-driven innovation, because Green Building is a concept that is broadly demanded by customers. This is a view that is reinforced when talking to MKB: s Construction Manager (Persson, 2010); according to him, firms have no choice but to focus on Green Building. However, regardless of the pressure from regulators and customers, it is relevant to discuss what is necessary and what can be used as a competitive advantage. It is natural that some companies will have a more ambitious approach toward green building and then use their skills as a competitive advantage. This will enhance the diversity of the skills apparent on the market and, in turn, path dependency, but in this case there no sign that it has a profound effect.

Furthermore, the Green Building standard is still relatively simple and non-complex according to Skanska's Project Coordinator (Hall, 2010) and NCC: s Regional Manager (Hedin, 2010). Firms do not necessarily need to change much to reach it, which also explains why path dependencies would be weak. In this case, the simplicity and the non-complexity of the product contradict that which is stated in the CoPS theory, but this divergence will be elaborated later on in the thesis.

The conclusion is therefore that path-dependency is weak in regards to green building; however, it is not necessarily like that in the whole industry.

The second part of path-dependency is treating standards. The empirical findings here show that it is too early to make a judgment about whether or not Schilling's (1999) theory: as the innovation process progresses, there will be a standard race for a dominant technology. Green Building is still considered to be in too early of a state to make that judgment. However, empirical findings (Hall, 2010; Hedve, 2010; Hedin, 2010; Persson, 2010) suggest that evidence of Schilling's theory is likely to emerge.

#### 5.4. User-Driven Innovation

- Large customers have a strong influence on the innovation processes
- Successful projects push the industry forward
- Customers are knowledgeable about the process and about what is feasible

The theories about innovation in Complex Products and Systems state (Hobday, 1998) that in a complex industry the customer, e.g. a real estate company, will have significant power over the product and therefore the innovation process. This is mainly because construction companies create unique solutions specifically tied to the customer's intended usage. Since this can vary significantly from project to project, the construction companies need to be flexible and have broad competencies. Therefore, the customer has more opportunities to affect what they are receiving. In contrast to *normal* markets of mass production, where the customer has limited knowledge about the products, the buyers in the construction market are usually large clients that have both the experience and knowledge to put pressure on the construction firm. The empirical findings are unequivocal, as all interviews (Hall, 2010; Hedin, 2010; Meiby, 2010; Eriksson, 2010; Hedve, 2010; Persson, 2010) support this argument. The Project Coordinator at Skanska summarized the general opinion by saying, "*all large customers know exactly what they want,*" and hence they give detailed instructions about how to do everything and they know what is technically and economically feasible.

MKB Fastighets Construction Manager (Persson, 2010) explains that they have considerable experience working with construction companies and therefore they know what they are capable of. In many ways, those driving the innovation process are the real estate companies because they are ordering new products with higher requirements than before and the construction companies are forced to adapt. The Project Coordinator (Hall, 2010) at Norra Hamnen gives the Citytunneln in Malmö (Malmö Subway) as an example, explaining that when it was constructed the buyer set very high demands on the environmental performance of the subway. Companies vying to get the project then increased their environmental performance of their construction practices. He also explains that, once a project has been done in a more efficient way, this becomes the new standard of the industry; the improvement of the industry moves ahead step by step. Citytunneln raised the standard of the industry, but it will most likely increase again when a new project pushes the industry forward, according to the Project Coordinator (Hall, 2010). This supports the view given in the theories (Hobday, 1998), that the user is a main driver of innovation.

As Skanska's Project Manager of Green Building (Hedve, 2010) explains, they are also trying to look at trends in order to predict what customers would like in the future, which right now is, among other things, an increased focus on greener building. This view further enhances the thesis that innovation is primarily user driven.

Additionally, the A&E Program Manager at Axis Communication (Eriksson, 2010) affirms this view by explaining that, when they are trying to sell surveillance cameras, they focus on influencing the company that is ordering a building. According the Project Manager (Eriksson, 2010), if the customer is convinced early in the project to include Axis products, Axis can increase their chances of changing the customers preferences in favor of Axis in the future as well.

However, there is another aspect of innovation that relates to the process. As exhibited by much empirical evidence (Meiby, 2010; Hedin, 2010; Hedve, 2010), as well as previous studies by Gann (2000), the construction industry competes largely on process innovation. Most companies can build everything, maybe with the exception of very large and complicated projects, and a main source of competitive advantage is their specific process efficiency. Higher process efficiency allows them to offer the customer the same product but for lower prices and a faster construction. In general, the empirical findings do not seem to show that process innovation is as user driven, but that it has more characteristics of a normal market. MKB fastighets AB Construction Manager (Persson, 2010) explains that they follow the law of public purchase (Lagen om offentlig upphandling), which all public companies do, wherein they choose the company that gives them the required building at the best prices. He also explains that other large private organization can choose freely. However, normal market rules are such that for an expected level of quality, a lower price and shorter time-to-completion are usually demanded. Therefore, there is a strong incentive for process innovation. Considering this, process innovation mainly follows traditional patterns.

## **5.5. Risk and Uncertainty**

- Predilection for known solutions and materials
- Large investments and uncertainty represent a big risk
- Focus on process innovation

According to Hobday's (1998) theory about complex products and systems, risk and uncertainty are two dominating features in a complex market. In the construction industry,

this is because every project requires heavy investments and it is difficult to estimate the success of the project over the life cycle. Hobday's (1998) findings have a clear support in the empirical findings as both NCC and Skanska (Hall, 2010; Hedve, 2010; Hedin, 2010) state that this is a problem and that a company cannot afford to be wrong. NCC:s regional manager (Hedin, 2010) explains that, because of high investments and uncertainty, the industry has a considerable amount of experience with bad investments, which has created a conservative approach towards new materials and technologies. The Regional Manager (Hedin, 2010) and the Architect (Meiby, 2010) provides Annehem, Lund as an example, where the industry imported a continental way of building without considering the long term effect of the Swedish climate on the housing. All failed investments like this one enhance the conservative attitude toward new innovation in the business.

The empirical findings (Hedve, 2010) show that the nature of this business has created a climate that has a strong predilection for known and tried out solutions, which limits the innovation process. The adoption rate for new materials is 15 years, which is considerably longer than a *normal* market, and which also supports the view that a precautious attitude toward new products hinders the innovation process. There is always a tradeoff between the risk of failed investments and the gains of the potential efficiency improvements that a new technology promises, and considering how large the risks are in the construction industry, the conservative view of new innovation appears to be rational. The empirical findings regarding product innovation are completely in line with Hobday's (1998) theories in that high risk and uncertainty are strong forces against rapid innovation and limit the scope of the innovation process.

Conversely, it is important in the construction business to make a distinction between process and product innovation. The empirical findings regarding process innovation (Hedve, 2010; Hedin, 2010) do not show that it is limited by high risk and uncertainty in the same way, thus the applicability of Hobday's theory is questionable on this matter. As this type of innovation can be limited to very small improvements and can be focused on a behavioral change, it does not necessarily require large financial investments. The process innovation also gives implications for the task of coordinating efforts (*which will be more in detailed discussed in the chapter complex value chain*), which is an essential part of process innovation. Moreover, empirical findings show (Meiby, 2010; Hedin, 2010) that since most construction projects can be executed by the majority of companies, process efficiency is a main source of competitive

advantage. Therefore, the same conservative attitude that exists with respect to product innovation is not as apparent when it comes to process innovation.

The risk has implications for other factors that affecting the innovation in the industry such as trust. To mitigate the risk of a project the firms must, according to Gullati et al. (2000), be able to build long lasting relationships with other participants in the network and through that be competitive towards other companies and their network. This also have implications for the transaction cost that is lowered by building trust since uncertainty is a central concept in TCE (Williamson, 1985).

### 5.7. Complex Processes

- Risk for sub-optimization
- Important with common-goal coordination
- Network innovation can lead to competitive advantage

According to Gulati et. al (2000), one of the main challenges for a network is to coordinate the efforts towards a common goal and utilize the resources within the network to achieve this goal. It is important, from a strategic point of view, to be able to coordinate and be striving to develop the network because this can be a main source of competitive advantage against other construction firms (Jarillo, 1988). An important piece to the puzzle is that all activities undertaken should, in the end, create value for the customer. The advantages of the network have been mentioned, but there are still some conflicts defined as sub-optimization for the parties involved. NCC: s Regional Manager (Hedin, 2010) emphasizes that it is important for everybody in the network to create value and that self-interest in the network risks moving in the direction of sub-optimization. The Architect (Meiby, 2010) agrees with this view and explains that vested interests can limit improvements and change. Both of these statements support a view that, in a complex organizational network, vested interest can limit the scope of innovation.

As discussed in the risk section, the profit margins are low and the investments are high, which means that an improvement in the network that leads to a higher economic efficiency is invaluable. In order to effectively integrate of ideas, Malm et. al., (2001) states that it is important to make participating firms work toward a common goal. This view is supported empirically by NCC: s Regional Manager (Hedin, 2010) which articulates that this one of their greatest challenges in the network.



An important extension of the *knowledge web* is that it can be used to analyze a network by raising questions about who is taking the initiative for the participants in the network. Here it seems that the construction company is taking a great deal of the responsibility for developing the network, as in the case of “exporting” the 3D-blueprints concept to the network. This is a feature that one can attribute to the network theory outlined by Jarillo (1988) and Gulati et. al (2000). It also seems that The Architect (Meiby, 2010) is taking some responsibility because he is also involved in the actual development of new concepts such as green building.

The suppliers that are tied to the construction company may see some disadvantages: they do not appropriate the value because they are subordinated in the network. Another party involved, which seems to have a greater impact than initially thought, is the wholesalers who, according to NCC’s Regional Manager (Hedin, 2010), are using their monopolistic position to increase their prices and therefore put pressure on the construction companies. It is hard to integrate them into the value chain because they are not interested in striving toward the goal set by the construction company. On the other hand, it is not certain that the construction company offers the best process solution, although it bears most of the responsibility. The construction industry is looking for several ways to get around this. For example, Skanska tried to integrate the value chain backward so that they could appropriate the value created in that phase of the value chain. Similarly, NCC tries to create strategic partnerships with suppliers by promising a certain annual level of investments in return to for increased spending on innovation from the supplier side. This change in the network organization is a sign of process innovation.

Regarding transaction cost economics, Williamson (1985) states that when the network becomes more integrated, frequency plays an important role in lowering transaction costs. By forming strategic partnerships with suppliers, each building project can strengthen trust and therefore increase the value in the network. If the same suppliers are used many times and in different settings for different projects, bonds will develop; these partnerships are one of the main advantages of working within a network, according to Gulati et al (2000). These partnerships result in lower transaction costs and thus facilitate innovation in a network.

## **5.6. Unique projects and Cost**

- Hard to transfer knowledge from one project to another
- Oligopolistic cost structure among suppliers

Since the industry is organized mainly in project form where a unique set of contractors are coordinated for a unique project in a unique context, there are problems with transferring knowledge from one project to the next. Experiences from the first project might not be applicable in the next because of a different context and product nature. Contextual obstacles can also be overestimated, resulting in that important knowledge failing to be transferred. The empirical findings show that this is an issue for the industry. Skanska's Project Manager (Hedve, 2010) explains that, because of this challenge, they attempt to transfer as much knowledge as possible from one project to the next by trying to understand how the context shapes a specific project. This is in line with previous studies (Widén, 2006), as well as theories regarding innovation in CoPS (Hobday, 1998). Transferring knowledge between projects makes the innovation processes slower, because many new ideas are not applicable to all projects and the challenge understanding how improvements in one project can be applied to another with a different contextual reality results in knowledge being lost and forgotten instead of transferred.

Furthermore, as interviews with The Architect and NCC:s Regional Manager (Meiby, 2010; Hedin, 2010) illustrate, the industry is characterized by self-interest and everyone is trying to sell their concept, despite the fact that it may comprise parts of the project. For the construction companies, the supplier market has oligopolistic tendencies which results in high prices of supplies and with few opportunities to bring them down. Consequently, most construction companies focus on innovating in the process instead of the product because it is hard to change the cost of materials.

## 5.7. Overview of Findings

Factors	Theoretical Assumptions	Empirical Findings	Comparison
<b>Regulations and Standards</b>	Regulations and Standards guides innovation	<ul style="list-style-type: none"> <li>- Affects the industry</li> <li>- Creates a new Cost of Entry</li> <li>- Is weaker than first assumed</li> </ul>	<p>Market is ahead of regulations which limits their impact. However they still provide guidance on where the market is heading.</p> <p>Standards, i.e. what defines green-building, are pushing the industry since they represent something that the market recognizes and demands.</p> <p>Further, one cannot choose to build non environmental friendly. The cost of entry increasingly requires higher environmental standards.</p>
<b>User Driven Innovation</b>	Customers have a large influence and drives the innovation process	<ul style="list-style-type: none"> <li>- Large customers have a strong influence on the innovation processes</li> <li>- Successful projects pushes the industry forward</li> <li>- Customers are knowledgeable about the process and what is feasible</li> </ul>	<p>Above all it is large and knowledgeable customers that stimulate innovation process (which makes up the majority of the customers) and they take the opportunity to put substantial pressure on the construction firms.</p> <p>Other customers can also affect but usually not as strongly.</p>
<b>Risk and Uncertainty</b>	Heavy capital investments as well as complex products and ambiguity in customer demand and material performance over a life-cycle leads to a conservative	<ul style="list-style-type: none"> <li>- Predilection for known solutions and materials</li> <li>- Large investments and uncertainty represents a big risk</li> <li>- Focus on</li> </ul>	<p>Empirical findings are in line with the theoretical findings: The industry has a bias for old solutions that represent less risk.</p>

	attitude towards new materials, products and processes		process innovation
<b>Path Dependency</b>	<p>Previous investments efforts have an effect on future competitive advantage and investments.</p> <p>New standards lead the way to a standards race</p>	<ul style="list-style-type: none"> <li>- Path dependency weaker than expected</li> <li>- Broad competencies are needed</li> <li>- Green Building pushes the Cost of Entry which limits path dependency</li> <li>- Green Building is relatively non-complex</li> </ul>	<p>Empirical findings suggest that path-dependency in the industry referred to company specific technical know-how tends to be weak since construction companies needs to be relatively proficient at a wide range of competencies.</p> <p>Path Dependency still seems to be apparent when it comes to process innovation. Dominant standard is apparent when new processes and products come.</p>
<b>Complex Processes</b>	<p>Strong dependencies on other participants in the network. Risk for sub-optimization when firms looks to themselves. Potentially hard to coordinate innovation efforts.</p>	<ul style="list-style-type: none"> <li>- Risk for sub-optimization</li> <li>- Important with common-goal coordination</li> <li>- Network innovation can lead to competitive advantage</li> </ul>	<p>Mainly in line with preliminary findings. It is hard to coordinate everyone to a common goal since the network is driven by self-interest.</p>
<b>Unique Projects</b>	<p>Every project is tailored to a specific customer which makes it hard to exchange information from one project to another</p>	<ul style="list-style-type: none"> <li>- Hard to transfer knowledge from one project to another</li> </ul>	<p>The empirical findings shows some support for the hardship of knowledge transfer however many things are still similar and therefore it is possible to use previous knowledge on new projects.</p>
<b>Other - Cost</b>	<p>Not in the selective theories, but a factor that generally stimulates innovation.</p>	<ul style="list-style-type: none"> <li>- Oligopolistic cost structure among suppliers which results in high material cost</li> </ul>	

## 6. Conclusions

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*The thesis aims to describe the innovation process in the construction industry from a contextual perspective. The main contribution of the thesis is the application of the integrated framework that gives a comprehensive understanding of the innovation process. This chapter also discusses the way it should be applied and the implications of this. A general restriction is that the Swedish construction industry is unique in its nature, which limits its applicability to the sector.*

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### 6.1. Strategic Advice for Practitioners

In an industry, the need for guidance and direction is essential. The factors that this thesis presents as part of an integrated framework should be used as a tool for managers to gain a comprehensive understanding of how context affects the innovation process. For managers in a strategic decision making position, it is important to keep the following ideas in mind:

Since the firm is dependent on integrating the processes of a wide range of stakeholders, the construction company's strategic decisions must cater to the surrounding environment. Knowledge about how the industry and network actually work is an important factor. Additionally, the innovation process in the construction sector is unique compared to many other industries, so understanding the framework is an essential tool for a newly recruited executive from a different industry. A new executive should reconfigure his or her views on how the innovation process works rather than applying old knowledge from an industry that is fundamentally different from the construction industry.

For new managers, it should be emphasized that the user driven perspective is the key determinant in pushing through one's agenda. Convincing the customers about the superiority of a solution puts pressure on the industry to supply this solution.

Transferring project details is complicated and for managers it is an issue of vital importance wherein a firm strives to maximize the amount of knowledge and experience transferred from one project to another. One way of overcoming this inefficiency is by standardizing projects, which would remove much of the knowledge transfer complications. However, standardization also has negative outcomes, such as lower customer satisfaction.

Due to the high risk of new investments, much of the competition in the construction industry revolves around processes. It is especially important for smaller companies to keep in mind that the risk of new materials is critical, as failed projects tend to be very costly.

For suppliers in the industry, alignment with their network may be beneficial even though the advantages are harder to discern due to suppliers being integrated behind the construction company in the value chain. The difficulties stemming from being further from the end user/customer in the value chain can hinder the integration process. On the other hand, if the construction company manages to create a long term relationship with the suppliers these difficulties may be fended off.

## 6.2. Theoretical Contribution

The primary purpose of this thesis is to utilize existing theories in order to explain how the context in the Swedish construction sector affects the innovation process. Secondly, the purpose is to match the empirical findings with the theories and see how well they confirm existing knowledge or further explain specific parts of the employed theories.

The result of our study is that the theories have, for the most part, been confirmed by the empirical findings. The findings on user driven innovation support the theoretical framework previously outlined in the thesis. Network theory regarding *complex processes* has also been significantly backed by the study. Path dependency, on the other hand, has not been confirmed as a significant factor in green building's current stage of development. However, it is not entirely inconsistent with the relevant theories, because in this case the limited impact of path dependency in the innovation process is mainly a result of the study-object chosen, which is still in a very early stage of development. This will be further elaborated in the chapter *implications and applicability*.

Nevertheless, the main contribution of the thesis is the *framework as a whole*. Integrating all the factors when analyzing the industry gives a comprehensive understanding about how the industry works and what can be done to increase the success of innovation.

Additionally, there are a few factors where the empirical findings are slightly different than what was initially expected and this should be further discussed:

*Regulations* – The theories here are mainly based on markets with mass produced goods and therefore state that government regulations can be used for pushing the market forward in the *desired* direction. These theories discuss a reality where regulations are ahead of a large part of the market, whereas the thesis has studied a situation where the industry has a substantial lead over the regulations that are imposed on the market. However, the results have demonstrated that the industry participants' anticipation of increased regulations affect the

market. This has led to the same results as theories predict, though the relationships are not as strong as formerly supposed. This results in a theoretical gray area that would benefit from further investigation.

*Complex Products and System* – in the CoPS theory, complexity is mainly analyzed as a product of system hierarchy and product complexity (or technological uncertainty/ novelty). Green Building was initially thought to be quite complex with regard to technological uncertainty and novelty, as new technologies were assumed to be necessary in order to reach additional standards. However, green building is presently a product of new applications of already existing technologies. The complexity in the construction industry, when it comes to green building, is mainly a result of complicated processes. A construction project requires, as stated many times before, the coordination of many different companies toward a specific goal, which quickly becomes very complicated. This is where the majority of the complexity lies in the construction business and it is also where a considerable amount of the innovation takes place. Complex coordination is discussed in the CoPS theory, especially the complications arising from working in project organizations, which is the main platform for coordinating CoPS projects. However, it would be interesting to further elaborate this as it is not necessarily so that an industry with complex products and systems behaves in the same way as one where most complexity lies in its processes. Perhaps they are very similar; in this specific case, the CoPS theory is highly relevant and offers substantial explanatory power to the thesis. This may be because the unique nature of every project results in higher technological uncertainty/ novelty, which increases the dominant factors in CoPS projects, risk and uncertainty. This is a plausible explanation, considering that an industry that is only complex in its processes would most likely not be characterized by high risk and uncertainty, because the technologies and materials already are tested.

There are a few empirical findings that have not been explained by the chosen theories, such as the tendencies of a monopolistic cost structure in the industry where suppliers have some power over the market price. Though it has not been confirmed by theories, this is thought to be another limiting factor to material innovation, as it makes the system inflexible.

### **6.3. Implications and applicability of the proposed framework**

The thesis has reached some interesting conclusions and this section will answer how the findings can be used in other contexts or industries. The findings can be used in a similar context, which corresponds to the way in which the purpose was outlined. As discussed in the introduction, the construction industry is not working as a market for mass-produced goods: one of the main reasons for this is that the user is more involved in the creation process than a user in the market of mass produced goods, where the producer in general is more dominant. This user driven perspective influencing the construction industry is significantly affected by unique projects. However, in the construction industry, unique projects are one of the factors slowing the innovation diffusion process down. The main reason is that the spillover effect from one project to another is wrought with inefficiencies.

Furthermore, path-dependency is minor due to the broad competencies demanded by different projects and the current non-complexity of green building. Due to the fact that green building is in high demand by both customers and regulators, it is less likely to be subjected to path dependency. By creating a new cost of entry to the market, green building establishes itself as one of the main focal points of industry participants. Therefore, companies do not risk forgoing other innovation opportunities by following through on green building strategies. However this is not necessarily the case when it comes to other innovations in the construction industry and one cannot make a general statement from the empirical findings of this study that path dependencies are weak throughout the industry.

However, standards are important because they allow parties involved to have a common goal to strive after. This is strongly tied to the impact of regulations, and the results from this study can be used independent of how strong the regulations are. For example, before the 1990's the Swedish construction industry was heavily regulated and it forced the industry to build by the rules set up by the government. The same thing applies today, but less so, because regulations are not as strict as before.

The cost factor is easy to generalize to other industries since it is always a top priority for companies to minimize costs. The way in which the construction industry strives to be more process oriented and coordinated is an approach that other industries attempt to imitate. (See the "Toyota way" generation of companies).

What is unique about the results of this study is how the factors of the framework interact, which can be utilized to provide a comprehensive understanding of the way context affects



the innovation process in the construction industry.

#### **6.4. Future research**

The initial approach to the purpose has been focused on contextual factors. The framework developed in this thesis has settled a variety of factors and also how strongly they are affecting innovation in the construction industry. The perspective chosen in this thesis does not answer how these factors are handled by the parties involved in the industry. This study suggests that one would benefit from further studies in the following areas:

*Rate of adoption* - The construction industry is very conservative towards new solutions and the rate of adoption is rather slow. Clearly, new innovations in the industry could be an effective way of gaining a competitive advantage toward others but the risks of trying these innovations trumps the potential gains. How can companies organize their R&D centers more effectively so as to diminish risk and increase the adoption rate in order to allow for more frequent innovation?

*Legislators* - Since the legislators are influencing the industry, could they increase regulations, making the industry even more environmental friendly? Swedish construction companies are among the leaders of green building in the world. It could be of great interest to compare how different legislations affect the market, comparing it to other countries and other contexts, and thus determine what legislations having the most desired effect.

*Organizational approach* - Since this thesis has focused on industry factors, an internal perspective is completely left out of the equation. Here, the firms are facing different challenges; presumably the minor parties have to organize in a different way than the considerably bigger construction company. Taking an organizational approach to innovation could have interesting results, especially how the parties are integrated and to what extent.

*Network* – This thesis has made a contribution to network theory as presented in the analysis section. What is actually missing is that there has been no perspective taken from either Industrial organization or RBV. However, there are some interesting findings that may be explored further, such as the uniqueness of the network, and in this case it would be interesting to take a RBV perspective on what features the network has.

*Developing a universal framework for complex systems* - The factors used in this study are more or less universal and the CoPS theory is a step in the direction of determining what is distinguishing complex contexts, with construction being one of them. The factors used in this study could be attached to other similar and non-similar complex contexts. By developing new frameworks and compiling them, a universal framework for complex systems could be developed.

## **6.5. Variation of the Conclusion**

The construction industry needs to accept a great deal of compromise when coordinating different companies in a network. One must in real life also come to terms with the dimensions of compromise. Compromising and coordinating a variety of contrarious interests can be compared with politics. It is seldom that a decision is bought by everyone who is affected. Some may look to their own interests, resulting in sub-optimization. On the other hand, it may be difficult to separate right from wrong, as the nature of politics often incorporates an opinion. Drawing from this reasoning and considering what has been discovered in the construction industry and the concept of green-building, it has been surprising how little politics have been involved. This is because everybody is picking up the concept without any reservations; the facts show that this is the best thing to do. The political environment wherein a party, decision, green-building concept, earns a 100% “Aye” is very rare. Everybody wants the concept: regulators, customers, construction companies, and therefore it creates very little friction. Compare this line of reasoning to the great environmental debate where countries are trying to conclude a set of rules or guidelines for each country: not that frictionless. The only conclusion as to why this is the case depends on to what extent one is affected. Returning to the analysis and the non-complex nature of the green-building concept, it might be that everybody gains. Who would not be able to sell a concept where there are only winners? Imagine a lottery with only winners and no losers. An interesting thought in the same domain is that a politician often states the superiority of an idea and oftentimes, amid the rhetoric, it is forgotten that this idea incorporates opinions and not just facts. Hence, it is important to constantly rethink your opinions, as old ones hinder winning ideas and facts. This may seem basic, but in business this is far away from the case; compromising, faith, hope, trust, self-fulfilling prophecy, and so forth are all a part of the game. On the other hand, hindsight is 20-20. For example, producers used to produce with no regard for customer preferences and superior performance depended on perfect quality. The task to come up with examples is given as an assignment for the reader. To finish the

discussion above about frictionless strategic decisions, consider the following: a most interesting case, when one wishes to push an idea through the network, is to choose an idea that has garnered unanimous support so as to observe the efficacy of innovation within the market relative to what a controversial idea would push forth in the same amount of time.

## 7. Appendix

### 7.1. Sources

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## 7.2. Questionnaire

### Respondents

Name:

Position:

Background:

### General questions

How was the Green Building concept received when introduced?

What are the significant events up until today?

Who possess the status in the network?

To what extent are you dependent on others in the network?

How valuable do you experience the network you are in?

Do you experience the network to be unique in any manner?

Is the network flexible?

Do you experience a competitive pressure from outside the network?

What is your thoughts regarding the trust between the participants in the network?

### Innovation from regulation

How is the environmental friendly innovation process affected by the authorities and regulations?

- Certifications?

- Standards

### **Coordination and interaction (vertical and horizontal)**

How do you coordinate the innovation processes in the network?

### **Path-dependency**

Is your long term prioritization affecting the innovation efforts?

Are earlier mind-sets affecting the direction of these efforts?

What is your attitude to new ideas from others in the network?

Do you find it hard to export your strategic ambitions to the network?

How do you import other ideas into your solutions?

### **Risk**

How do you work with risks internally in your innovation projects?

How do you assess risks across the supply chain, whose projects must succeed before yours can?

Who has to adopt certain innovations before you commercialize it?

Which “job to done” are you able to outsource and which not? Why is it so?

### **Uncertainty**

Are customers and suppliers exchangeable?

How dependent are you on others to succeed with their innovation-projects, are there any dependencies at all?

### **User-producer driven**

How do tackle the integration process with the customer, especially the customization with each?

We have identified these factors affecting the innovation process in the construction industry in a unique way, are there any other factors you are thinking of that might have a substantial effect on the innovation process?