CHALMERS
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Changing the Architectural Role

By Implementing Early Cost Estimations

Master's Thesis in the Master's Programme Design and Construction Project Management & International Project Management

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Visualisation of Kvillebäcken, Göteborg, a project example of the case firm Liljewall Arkitekter.
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ABSTRACT

Cost estimation has been stated to be an essential part of all construction projects. Today cost estimates are performed in different stages by different actors, however, it is generally not a part of the architectural practice. In the design phase, each change in choice of design will impact the total project cost, but despite this, architects have been seen to be poor at being cost aware. It has further been stated in research that cost estimates are made too late in projects, which often leads to compromises being made on the design later on. Further, research on cost estimates in projects raising the architect focus and perspective is limited. This study sets out to investigate this gap, and looks at cost estimations from the architect perspective. Among the different existing methods and tools for cost estimations, are ones based on Building Information Modeling (BIM). However, it has been questioned whether all available tools are applicable for early stages of projects, and further for the architect profession. The main objectives of this study have been to identify the values and challenges for architects in performing cost estimations in the early design phase, and to identify whether BIM could impact or support this. Consequently, if new cost estimation processes or practices within an architectural firm are to be implemented, there are factors important to consider. Therefore, this study looks at implementation management, including barriers and challenges one might be facing. This study can be especially valuable for architect firms looking to see how their practices could develop. The research methodology included a theoretical review, as well as a case study at an architectural firm where 11 semi-structured interviews were conducted. Additionally, interviews were held with two clients of the architect firm. Main findings of this study include that there are many values in architect firms performing cost estimates and simultaneously raising their overall cost awareness. BIM was concluded to be able to support in this context. However, there were also challenges found in this context; some specifically related to architects being able to do such, some concerning the internal processes, and others more general. The values of these cost estimates were concluded to be largest internally for the architect firm itself. However, findings suggest that winnings can be concluded to exist also on the broader perspective, by increasing the project cost dialogue between all parties involved on the project and leading to overall better project outcomes.

Key words: cost estimation, BIM, architecture, implementation management, early design phase

Contents

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Ellinor Johansson
Emma Johansson

1 Introduction

This introductory chapter aims to present the reader with a background to the subject of research in order to present its relevance of study. In addition, a gap in research within the subject is outlined and indicates the need for this research. Further, the purpose and objectives of this paper are defined and research questions aimed to be answered are presented. Additionally, its limitations are addressed. Finally, a shorter description of the structure of this report is presented.

1.1 Background

Cost estimation is an essential part of all construction projects. It is a general business interest to, as accurately as possible, be able to estimate the project construction cost throughout the whole project process. This typically to: estimate project budget as accurate as possible, ensure that bids are within budget, ensure alignment of budget and client requirements, and minimize risks because of budget overruns (Sundaram, 2008). Generally, when speaking of project cost estimates, it is construction costs that are thought of. Bragança et al. (2014) define construction cost as "the costs related to each process needed to build the building", which includes: costs of acquiring materials, cost of construction equipment, and the cost of manpower. Estimating project costs can be challenging, as many complex factors need to be considered, such as type and size of project, soil conditions, material costs, likely design and scope changes, duration of project etc. (Ahiaga-Dagbui and Smith, 2014). In the earlier design phase, there is often a high uncertainty concerning the above mentioned factors, which means that estimations are even more challenging in this phase of projects (Ahiaga-Dagbui and Smith, 2014).

For the architects, each change in choice of structure or material will mean an effect on the total project cost. Despite this fact, architects are seen to be poor at being cost aware and the role of calculator is instead undertaken by the client and contractor. As said by Ahiaga-Dagbui and Smith (2014) and Sundaram (2008), the ability to influence final costs is far greater in early project stages than in later. The traditional way of estimating project costs in construction is to do so based on 2D drawings out of which quantities are measured (Kim et al., 2013). Due to the considerable time and expenses needed to perform analyses like cost estimations (based on traditional 2D methods), these are primarily done at the later stages of projects (Eastman et al., 2011). As a result of these estimations not being made in the early design phase, compromises to the original design often have to be made later on in projects (Eastman et al., 2011). This fact directly affects the architect; as important design values can be the ones that have to be compromised.

Intelligent cost estimation systems based on Building Information Modelling (BIM) have been widely recognized in research studies and literature (Kim et al., 2013), and are to some extent applied in the industry today. Further, the Scandinavian region is said to be one of the strongest in BIM implementation and development (Smith, 2014). However, information rich BIM models are foremost used for the operational phase of projects (Yin and Qian, 2013). At the same time, it is becoming more common for architectural firms to use BIM tools already from early sketching stage. As information from BIM models can be collected also from early stages of

modelling, it is of interest to identify the possibilities of cost estimation based on this information.

There is much literature and research on cost estimations targeted towards the later phases of projects and from a contractor's perspective. However, there is a gap in research and knowledge concerning cost estimations at the early design phase. Therefore, it is of interest to look into if and how costs can be efficiently estimated at an early design stage of a construction project's life cycle.

1.2 Purpose

The main purpose of this research study is to identify potential values and challenges of project cost estimations at early design stage primarily from the architect's perspective. Further, to investigate if and how recent development within BIM can impact or support in an early cost estimation. Additionally, the aim is to identify the factors that need to be considered in implementation of new cost estimation practices, for the organization as well as the project process.

1.3 Research Questions

This study is guided by the following four research questions:

1. What are the values of cost estimation for architects at an initial design stage of the project process?

2. What possible problems and challenges might impact on cost estimation at the early design stage?

3. How can recent development within BIM impact or support an early and efficient cost estimation?

4. What factors are important for implementing early cost estimation for the architect organisation as well as for the project process?

However, first it is of importance to define cost estimations and what it includes at an early design stage.

1.4 Scope and Limitations

This research looks at cost estimations in the early design phase of construction projects, primarily from an architect's point of view. Cost estimations in this study is generally defined as estimation of project costs directly connected to the construction phase. Early design phase is in this thesis work defined as constituting the first Conceptual phase and the following Predesign phase of the design process in projects, see Section 2.2, and Figure 2.1 for illustration and further description.

The main focus of this study is on the architects' point of view, however, the perspectives of the client and contractor are also included and discussed. This case study is limited to an architectural organization within the Swedish construction

industry. However, the subject is discussed in the wider context of the Swedish construction industry and also on the international level.

1.5 Structure of Report

Firstly, this thesis starts with a literature review, which forms the theoretical framework of this study. Focus in this section is on cost estimations in early design phase, available methods for early cost estimations, and recent development of BIM and its usage areas in the described context. Moreover, theory on implementation of new practices, and potential barriers and challenges for an organization and its project process are presented.

Secondly, the methodology of this study is described in Chapter 3. It is discussed what type of research approach and design that have been applied as well as methods that have been adopted for data collection and analysis.

Following, Chapter 4 presents the findings of the conducted research. This part of the report categorizes findings according to suitable areas of subject in an order following that of the introduced research questions. However, a distinction is made between the perspectives of the architects and the clients.

The discussion in Chapter 5 aims to summarize and discuss earlier presented findings and compare these in the light of the theoretical framework of this report. Finally, conclusions are summarized and suggestions for future research are presented.

2 Theoretical Framework

The theoretical chapter initially discuss the past, present and future role of the architect. Additionally, a parallel is drawn to the Swedish construction industry. Thereafter, the early design phases of construction projects are described; the different contract types most commonly applied, and the actors involved in the project process. Further, a presentation of values and challenges of early cost estimations recognized in literature are outlined. Then, factors that in this research context are concluded to impact on methods for early cost estimation are addressed. Moreover, existing methods of project cost estimation and the role of developed BIM technology in this context is reviewed. Finally, theory regarding implementation of new practices, and potential barriers and challenges for an organization and its project process are presented.

2.1 The role of the architect

The role of the architect has evolved over the years. The term architect originates from Ancient Greece where ‘‘arkhi’’ meant head chief and ‘‘tekton’’ meant builder (WordSense, 2016). According to a study looking into the architect’s past, present and indications of future practices, the current architect can be defined as “one who functions as the creator of the building’s design” (Burr and Jones, 2010, p.126). A comparison is made to a definition found in the Merriam-Webster Dictionary from 2006, where the architect is a person who not only designs but also advise and guide in construction. According to Burr and Jones (2010), the role of the architect today is in a new infancy, trying to find its new place, and this in a constantly evolving building industry.

The study by Burr and Jones (2010) emphasises the architect’s or “master builder’s” historical role as head responsible for the entire construction process. However, since the 19th century the construction industry has changed and become more complex, which has led to a higher level of specialization required. As a result, there has been a separation into two distinct professions: the designer and the builder. Even in the early design phase, where the role of the architect is still strong, it is evident that the number of consultants increases (Burr and Jones, 2010).

Subcontractors have developed within different areas of expertise. In other words, the construction industry has become fragmentized. Due to this, it is underlined that a successful construction project today is dependent on a numerous of professions working together. However, the industry’s fragmentation has led to elimination of a single source of responsibility and collaboration has become challenging due to the increased number of professionals involved in projects. The role of the project manager in construction, referred to as the construction manager, can be seen to have evolved as a response to this - a role that is most commonly undertaken by the contractor. These aspects, along with the design-build delivery system, see Section 2.2.1 In different contract forms for illustration, are seen to influence the change in the architect’s role. The latter, with an integrated design and construction team, results in time and money savings for the client (Burr and Jones, 2010).

In most cases, apart from design-build delivery projects, the architect is directly working for the client and project owner. Therefore, according to Burr and Jones

(2010), in an effort to understand the future role of the architect, the building owner can provide valuable information of what is to expect for the architect in the years to come. Based on their research findings, it is suggested that the architect who claims properties that have previously been included in their profession, increases the level of cooperation and communication with the builder, as well as explores new ways and alternatives of services will be successful in their profession and role. In this sense, the role of the architect is described has having to become more diversified than what it is today by broadening their knowledge of the entire project process. Further, it is suggested that the skills of the general contractor and the construction manager should be included in the design process, while the architect maintains a leadership role during the design process. New ways of services mentioned are adoption to the needs of building owners. In their study, these are forecasted to be looking for standards and guidelines for building projects (Burr and Jones, 2010). In addition, in the same context of new services, Burr and Jones (2010) refer to an example by Thomsen (2006) of a corporation, which has developed a cost history database for estimating new projects.

Ever since the 20th century, a tension has been seen in the Swedish construction industry between technology and aesthetics (Bröchner et al., 2002). Bröchner et al. (2002) identify the Swedish construction industry to be fragmentized. In addition, it is described that acquisitions and mergers have resulted in three large construction contractors left on the Swedish market (Bröchner et al., 2002). In Sweden where this report's case study is carried out, the architect is not generally involved throughout the later stages of the project process in projects of the character Design Bid Build contract form, see Section 2.2.1 for further description. Bröchner et al. (2002) emphasize that there is a difference between Swedish architects contrary to the ones abroad, arguing that the Swedish architects have a narrower role in the construction phase. Further, this difference can be identified even in comparison to the neighbouring countries of Denmark, Finland and Norway (Bröchner et al., 2002). As one aspect to this, Bröchner et al. (2002) discuss the educational aspect of the architectural profession and conclude that there is a large gap between the area of civil engineering and architectural studies in Sweden. Further, rather than having developed building as a separate field of expertise, the area of civil engineering has broadened (Bröchner et al., 2002).

2.2 Early design phase

The stages of a construction project can be seen described in different versions by different authors, even though the phases and their overall goals generally are the same (Bragança et al., 2014). In this dissertation, however, the project process will be described as in Figure 2.1, a linear process, consisting of the following phases: Conceptual phase, Predesign, Design, Tender, Construction, and Use. Further, Early design phase is in this dissertation defined as including the first Conceptual phase and the Predesign phase, see Figure 2.1. According to Bragança et al. (2014), the following description of the design approach process is applied by the majority of firms with a general design purpose.

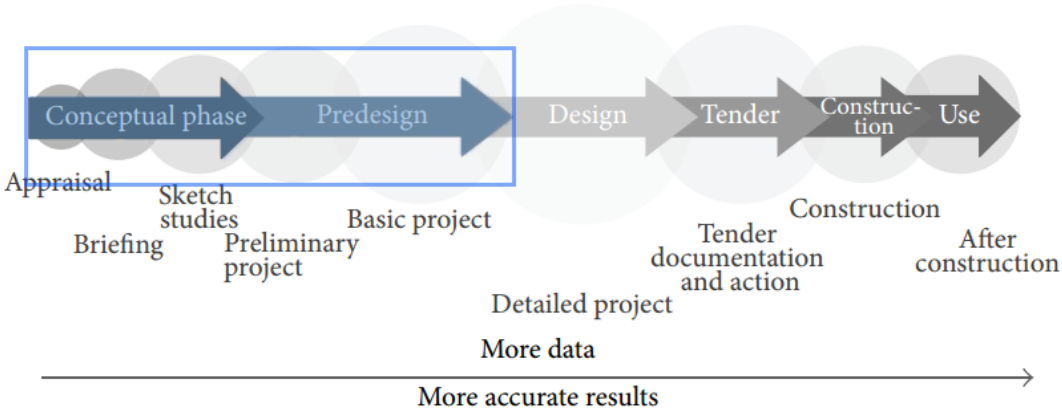

Figure 2.1 Design stages and highlighted early design phase of a construction project. Based on Bragança et al. (2014, p.4)

The conceptual phase starts with the design team meeting with the client in order to define the objectives and goals of the project (Bragança et al., 2014). The exchange of information in this initial phase is what contributes to the development of the project's concept. Type of architecture, functional aspects, and environmental and energy requirements are aspects considered at this stage. Further, information about the site must be available and an evaluation of the circumstances for construction has to be done. In addition, it is in this phase that type of procurement method, along with project cost and timescale are dealt with. The conceptual phase is emphasized to be the most crucial phase, since the possibilities to design and innovate are greatest in this stage. This initial phase puts the client's request into practice and visualises the design team's project proposal (Bragança et al, 2014). Worth mentioning is that the design team in this phase, according to Bragança et al (2014), includes the architect, engineer and other needed specialists. Further, the conceptual stage is where the overall system configuration is defined. However, the data available is very scarce and any evaluation that is done at this stage has to be made mainly on assumptions. At this stage, there are no details about the building, only information such as the construction area and height of the building. Detailed work of every technical expert remains at this stage (Bragança et al, 2014).

The second phase Predesign, starts after approval of sketch studies. The general shape of the building is further developed through drawings of plans, sections, elevations etc., and the provisional decisions from the conceptual phase is either confirmed or modified. It is traditionally also in this stage that type of construction and materials are decided upon. In addition, functional relationships between different elements and volumes are examined. Equipment such as types of windows and doors, elevators and suitable manufacturers are decided upon. At the end of this phase, structural, mechanical and electrical engineers are asked to implement the design and suggest appropriate systems. This information then provides the base for a more accurate estimation of construction costs. (Bragança et al., 2014).

2.2.1 In different contract forms

According to Bragança et al (2014), the early design phase is in general carried out with a similar approach irrespective of contract type. However, the level of

involvement that different actors have in the project process can depend on what type of contract form that is used. Following below are the two most common contract forms: Design-Bid-Build and Design-Build described. The more recent collaborative method referred to as Partnering is presented, as it is one growing work constellation in the Swedish construction industry.

Design Bid Build

In the traditional contract form, so called Design Bid Build (DBB) projects, the architects' involvement can be seen to stretch from conceptual stage up until tender documentation (Eastman et al., 2011). In this type of contract, the client and architect are the main actors up until tender. However, consultants in mechanical and electrical engineering, as well as designers of technical systems such as heating and ventilation are often contracted during later design stage, see Figure 2.1 (Bragança et al., 2014). In DBB, see Figure 2.2, there is what can be described as an adversarial relationship between the architect and the builder. In general, the architect takes on a representative role for the project owner during the construction process, with a responsibility to control and investigate the detailed work of the builder (Burr and Jones, 2010). The role of the architect as the project owner's representative also applies to the Swedish construction industry's earlier phases. However, Bröchner *et al.* (2002) emphasize that there is a difference between the Swedish architect's role overall, contrary to that abroad. It is argued that the Swedish architects have a narrower role during construction phase (Bröchner et al, 2002).

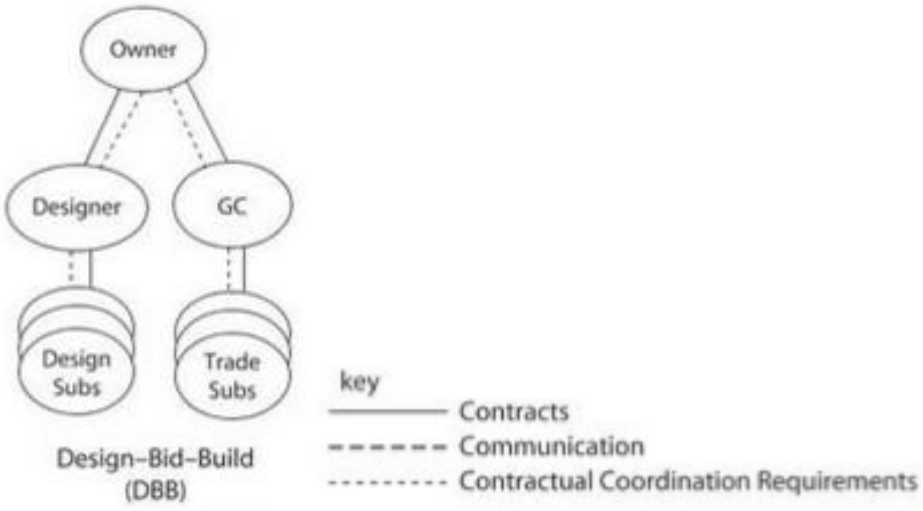

Figure 2.2 Schematic of DBB process (Eastman et al., 2011, p.4)

Design Build

In Design Build (DB) projects however, the main actors are the client and the contractor. In this type of contract, the DB contractor has either in-house design competencies or works together with an external architect. As opposed to the traditional contract form, the DB process, see Figure 2.3, places the architect and the builder on the same team, and thereby possibly helps in eliminating the adversarial relation and instead increases communication and cooperation (Burr and Jones, 2010). As concluded by Eastman et al. (2011), the DB approach was developed mainly to merge the responsibility of design and construction to one single party, and to simplify the administration work for the client.

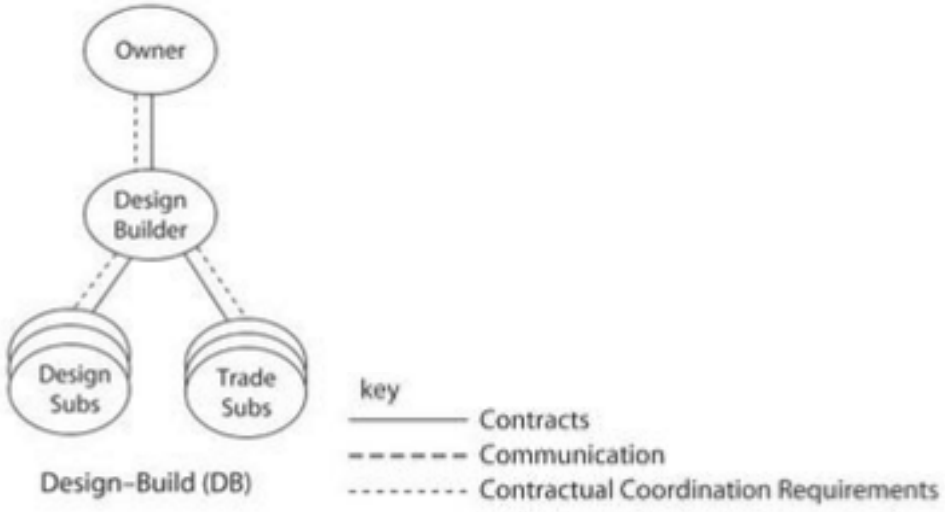

Figure 2.3 Schematic of DB process (Eastman et al., 2011, p.4)

Partnering

Much criticism has been directed towards the construction industry throughout time, criticism touching e.g. project performance, lack of integration, and its blame culture (Hartmann and Bresnen, 2011). As a result of this criticism, a search for more collaborative structures of arrangements started. As concluded by Hartmann and Bresnen (2011), the Partnering concept has come to represent the variety of collaborative methods between parties in construction. Its general objective is for parties to work towards a common project goal on the base of trust and understanding of each other's expectations and values. Thus, partnering can be a method used in e.g. a Design Build context. For example, Integrated Project Delivery (IPD) represents one of these collaboration contract types. It is characterized by the aim for effective collaboration between client, architects and contractors. Further, also consultants and subcontractors can constitute a part of the puzzle. This collaboration stretches from project start and continues through to project handover (Eastman et al., 2011).

According to Bröchner et al (2002), around the beginning of the 20th century, the Swedish Building Cost Delegation failed to identify collaboration between the client and the contractor as a way to improve the Swedish construction sector. Although at the time, UK provided good examples on the partnering concept. However, clients, even though being interested in new client-contractor cooperation methods, were concluded at the time to seem reluctant to changes of the traditional contractual arrangements. Further, it was then stated that such type of innovative cooperation was only applied on circumstances where time constraints were particularly strong or the project's uncertainty exceptionally high (Bröchner et al, 2002).

2.3 Cost estimations in early design phase

Cost estimations in this study can generally be defined as estimations of the costs directly connected to the construction phase: which as summarized by Bragança et al. (2014) include all costs from construction start to finish, such as costs of acquiring materials, cost of construction equipment, and cost of manpower.

In a single construction project, cost estimations are often done by several actors at different stages in the project process, e.g. by the owner and main contractors around and during bidding stage (Eastman et al., 2011). As of today, this job function does not generally exist at architectural firms but is rather located at other ends and mainly in later stages of projects. Further, as expressed by Dell'Isola et al. (2002), there has not been much done in order to improve architects' capabilities in cost management and estimating techniques.

During the conceptual design phase, cost estimations are done in order to determine the cost effect of certain design concepts and choices (Eastman et al., 2011). Cost estimations can be done in different ways during many stages of the design process, but Eastman et al. (2011) highlight the importance of doing such before the design is complete. According to the US study by Sattineni and Bradford (2011) the architect will traditionally not receive a cost estimate more than at the mid and end-points of each project design phase. Further, Eastman et al. (2011) says that as of today, analyses like cost estimates are normally done too late, which makes it difficult to make important changes. In the industry today there is more focus on cost control during construction phase than in the design phase, despite the fact that the ability to influence final costs is far greater in early project stages than in later (Ahiaga-Dagbui and Smith, 2014; Sundaram, 2008). In addition, Dell'Isola et al. (2002) emphasize that it is in the conceptual design phase that the architects must concentrate their efforts in ongoing cost control. Sundaram (2008) argues that cost management during the design phase is not that difficult as long as: a well-organized methodology and approach is used, team members understand their roles and "good estimating techniques" are used. However, noteworthy is that Sundaram (2008) sees the design team as generally consisting of the owner, the architect, and the cost estimator - thus an experienced professional in cost estimation is included.

2.3.1 Values of early cost estimation

According to Bragança et al (2014), the potential to optimize a building project, in terms of sustainability, performance and life cycle costs, is higher in the earlier phases of the project. The latter (life cycle costs) substitutes: construction costs, operational costs and end-of-life costs. Further, the impacts of changes at this stage results in less costs, comparable to changes being made later on in the project process. In other words, the influence of early design decisions plays a major role on the project's outcomes, both the environmental impacts and final costs (Bragança et al., 2014), see Figure 2.4.

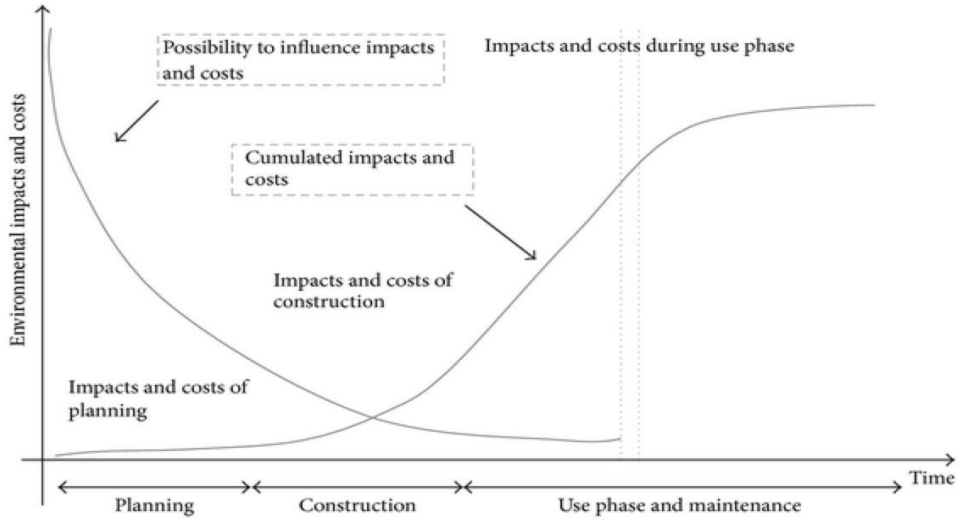

Figure 2.4 Influence of design decisions on life cycle impacts and costs Bragança et al., 2014, p.2)

Further, economic indicators, where construction costs is one of them, is concluded to be particularly important to include during the conceptual stage of a project in order to reach overall building optimization (Bragança et al., 2014). Moreover, as the conceptual stage often lacks information, the core indicators are chosen based on being considered possible to address under scarce data available. The indicator *construction costs* are given in price/m2, and its data can be obtained from databases of buildings' elements (Bragança et al., 2014).

Some of the main objectives of cost management in the design phase of a DBB context are outlined by Sundaram (2008): to estimate an accurate project budget, ensure that bids are within budget, ensure alignment with scope, budget as well as client requirements. Sundaram (2008) emphasizes the winnings that can be made through establishing an efficient cost management and project budget control already from the conceptual stage of projects. The main winnings can be presented as to: ensure the owner that there will be no budget overruns, and that the project is completed to required scope and meeting owners' objectives (Sundaram, 2008). Further, that early cost estimations minimize the risk of cost overruns. Researchers such as Sundaram (2008) and Bragança et al. (2014) stress that the ability to influence final project costs is larger in the early design phase than it is during later stages of projects. Therefore, it is of great interest to include cost management early on in projects for better overall cost control. Additionally, it is argued that benefits of a cost estimation model include support in the decision-making process (Bragança et al., 2014).

2.3.2 Challenges with early cost estimation

The design process is dynamic and the nature of projects at an early design stage highly uncertain. From the conceptual phase to the bid stage, the design of a project progresses significantly. Estimating project cost is overall not an easy task, and there are many aspects and complex factors to consider such as: type and size of project, ground conditions, material costs, likely the design and scope changes, duration of

project etc. (Ahiga-Dagbui and Smith, 2014). Since the early design phase means less certainty concerning above mentioned factors, estimations are more challenging at this project stage. Ahiaga-Dagbui and Smith (2014) mean that it can be exhausting to try to work out the influence of these mentioned factors in such an early stage, due to the uncertainty and scarce information about the project at this point. Dell'Isola et al. (2002) in their book "Architect's Essentials of Cost Management" go as far as saying that few things are as devastating to an architectural practice than a major project budget overrun. Dell'Isola et al. (2002) summarize the major consequences of this to be; a future client can likely be lost, profits can vanish, and the firm's reputation can be damaged.

2.4 Factors that could impact on methods for early cost estimation

There are many factors that could impact on cost estimations and how they are performed. Some of the main ones discussed in research are brought up in the following sections.

2.4.1 Project characteristics and contract form

It has already been mentioned that early cost estimations are challenging partly due to the uncertain character of projects in that stage (Ahiaga-¬Dagbui and Smith, 2014). Thus, in more challenging and risky projects, reasonable estimates can be even more difficult to achieve. The type of project and contract form could not surprisingly also impact on how cost estimations are or could be performed. Public projects e.g. have been argued to sometimes be underestimated by cost estimators in order to get approved (Ahiaga-¬Dagbui and Smith, 2014).

Further, the right contract form could also increase the chances of accurate estimates. As described by Eastman et al. (2011): in IPD (Integrated Project Delivery), which can be compared to partnering projects and promotes collaborative behaviour and allows contractors to get involved early in the design process, more accurate cost estimates can generally be developed earlier in the design. Conclusively, the impact of contract forms on methods for estimation is not widely discussed in research but does however make up an important part of this case study context.

2.4.2 The role of cost estimator

According to Smith (2014), the main professionals around the world, which provide cost management services are referred to as: cost engineers, quantity surveyors, construction economists, and project managers. In a single construction project, cost estimations are often done by several actors at different stages in the project process, e.g. by the owner and main contractors around and during bidding stage and later by subcontractors for their part of the project (Eastman et al., 2011). Dell'Isola et al. (2002) describe in their book *Architect's Essentials of Cost Management* architects from a US perspective, as leaders and managers of the design process, who are also expected to take on a leadership role in the cost management process. However, traditionally the architect will not receive a cost estimate more than at the mid and end-points of each project design phase, as mentioned in the study conducted in US by Sattineni and Bradford (2011). Conclusively, as of today, this job function does not

generally exist at architectural firms but is rather located at other ends and in later stages of projects.

Elfaki et al. (2014) highlight that cost estimation is a so-called knowledge-intensive task, meaning it depends on human professional expertise. To develop these skills can take years of experience and even this does not guarantee fair estimations. According to Elfaki et al. (2014), depending on the background and experience of the estimator, cognitive biases or errors in estimations can appear. Elfaki et al. (2014) conclude one of the main issues in cost estimating to be that this human knowledge is not documented or validated. As mentioned, according to Dell'Isola et al. (2002), not much has been done in order to improve the capabilities of architects in cost management and estimating.

2.4.3 BIM application

The development of computer-aided modelling tools has in the past ten years focused on supporting designers in increasing work efficiency as well as decreasing and eliminating design errors (Chi and Jiao, 2015). Building Information Modelling, further on in this report referred to as BIM, is one such modelling tool. Chi and Jiao (2015, p.136) refer to a definition of BIM, proposed by Eastman et al. (2011):

> "*BIM represents a modelling technology and a set of processes to produce, communicate and analyse building models, including sustainable practice, management issues around technology, and assisting methods*"

In other words, BIM is:

> "*A process involving the generation and management of digital representations of physical and functional characteristics of a project*"
> (Yin and Qian, 2013, p. 2148).

BIM can also be described as a process extended beyond 3-D model tools, including the three dimensions of width, height and depth into an additional fourth and fifth dimension; where time is the fourth and cost the fifth (Yin and Qian, 2013).

BIM is today widely used in the global construction industry, and has developed significantly since the early 21st century (Yin and Qian, 2013; Chi and Jiao, 2015). Further, the Scandinavian region is said to be one of the strongest in BIM implementation and development (Smith, 2014). In a study made by Sattineni and Bradford (2011), the three most common usage areas of BIM in decreasing order was concluded to be: visualization; architectural design and modelling; and clash detection. This is supported by Chi and Jiao (2015), who state that BIM through its functionalities can support the design process in several ways, including the three aspects just mentioned. In a study by Eadie et al. (2015), the perception and current use of BIM in the UK construction industry was investigated. It was stated that BIM can be used for a number of purposes including; developing and designing a 3D model, co-ordination of models (including clash detection), quantity take-off's, project and resource planning and BIM as usage for FM (Facility Management) operations (Eadie et al., 2015; Chi and Jiao, 2015). However, the latter, resource planning and BIM in facility management, was currently not seen as adopted in the

industry (Eadie et al., 2015). Further, Abdelhady (2013) state the earlier application of BIM as mainly having been adopted by architects and structural engineers.

Another advantage of BIM, which is commonly mentioned in literature is the functionality as support in collaborative work and for integration between the different building actors involved on a project; such as the architect and design team, contractor and the client (Abdelhady, 2013). Further, BIM enables detailed information to be added, shared and accessed by every party on the project (Abdelhady, 2013). BIM as a process can therefore be adopted and implemented on different levels, depending on the usage areas included (Eadie et al., 2015).

According to Chi and Jiao (2015), BIM is so far considered most suitable for use in the design and preconstruction phases. Yin and Qian (2013) state the different BIM applications specifically for the design-phase of a project as including: energy consumption simulation, system coordination, specification verification, collision check and structural finite element analysis. However, BIM in the early design phase can for some organizations mean only a simple 3D model, while for others these can be more information rich. However, even in early stages it is possible to assign considerable information to the building and its components. Eastman et al. (2011) stress the need for having an early model in a BIM tool software in order to be able to extract volumes and quantities needed for cost estimations. BIM as base for cost estimations will be discussed in the following chapter.

2.5 Ways of cost estimation in the construction industry

The traditional and still used method for estimating projects is based on 2D. However, several cost estimation models have been discussed in research to be advantageously applicable in the design phases of projects, such as CBR (Case-Based Reasoning), MRA (Multiple Regression Analysis), NN (Neural Networks), and BIM-based ones. CBR, MRA and NN are all methods relying on quality and quantity of data gathered from previous projects (Hyung-Il et al., 2012). The CBR cost estimation method is suggested to be most appropriate in early stages of projects (Zima, 2015; Ji et al., 2011; Kim and Kim, 2010). Eastman et al. (2011), conclude that each of the commercially available tools does only parts of the overall task that they should, which is basically described as: providing the balance of supporting the creative thinking process and at the same time providing fast assessment and feedback. In addition, it is described that translation is required between estimating tools and the basic BIM modelling tools (Eastman et al., 2011). Further, Dell'Isola et al. (2002) question whether the wide variety of automated estimating programs are really suitable for the architect profession. Instead an approach focused on design concepts rather than detail is encouraged (Dell'Isola et al., 2002).

2.5.1 Traditional 2D estimation

The traditional way of estimating project costs in construction is to do so based on 2D drawings out of which quantities are measured (Kim et al., 2013; VICO, 2012; Eastman et al., 2011). The time and effort needed for performing cost estimations, among other predictions about a proposed design, is according to Eastman et al. (2011) one of the most common problems with today's 2D communication. According to Sattineni and Bradford (2011), with traditional 2D based estimating

methods, the architect will receive a cost estimate at the mid- and end- points of each design phase of the process. This due to the fact that it takes up to three weeks for the calculator to generate each cost estimation (Sattineni and Bradford, 2011). As a result of the industry's need for more efficient cost estimation different intelligent software solutions have arisen and continue to develop.

2.5.2 Case based reasoning estimation

The so-called Case Based Reasoning (CBR) is a method through which one can estimate project costs. As its name indicates, it is based on previous cases and utilizes the knowledge gained from past experiences (Ji et al., 2011). The construction industry is experience oriented, and in such industries knowledge and judgement of earlier projects are essential to solve recurring problems. The CBR method works to some extent exactly as the experienced estimator would - using knowledge from previous experiences to solve reoccurring issues. The solution to a new problem is thus solved by gathering data from the most similar cases and adjusting them to the new case (Ji et al., 2011). Due to these features, one of the main benefits with CBR is that it is less dependent on the experience and expertise of the estimator (Ji et al., 2011). Further, the new solutions generated are stored for future use, once they are approved (Kim and Kim, 2010), thus building up the case library and strengthening future cost estimations.

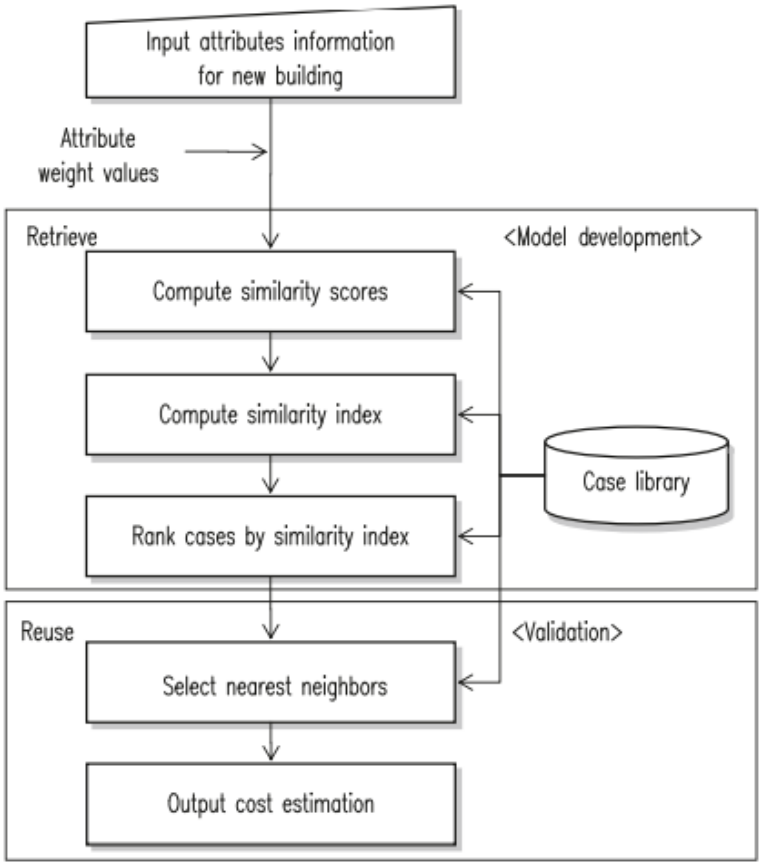

Figure 2.5 Process of a Case-Based Reasoning cost estimation (Ji et al., 2011, p.571)

According to Kim and Kim (2010), CBR is widely used by construction managers both in cost estimations and decision-making models. In the case studies performed by Kim and Kim (2010), the error rate when using CBR in comparison to traditional cost estimation models was found to be markedly reduced. The CBR cost estimation method is presented to be most appropriate in early stages of projects, and most of the research proposes CBR as a method for estimation based on the area unit price (m2) (Zima, 2015; Ji et al., 2011; Kim and Kim, 2010). As concluded by Zima (2015), the CBR cost estimation method can be advantageously used in the conceptual stages of projects, but it also requires a large database including previous cost calculations received through a great number of offer bids. Hyung-Il et al. (2012) also raise the issue of CBR depending on quality and quantity of previous project data, but also raise further issues: that it is still not easy to conduct estimates in the earlier phases of projects, and that for those not experts in construction, these methods could be difficult to understand. Further, researchers have also identified the challenge of weigh attributes (Ji et al., 2011; Kim and Kim, 2010), and Ji et al. (2011) conclude that more attention to this is needed in order to increase the reliability of CBR models.

2.5.3 BIM based cost estimation

Information and communication technology, such as BIM, has in the past years had a revolutionary effect on the development of the design process in the architectural, engineering and construction sector. Many researchers (Eastman et al., 2011; Abrishami et al., 2015; Yin and Qian, 2013; Smith, 2015) discuss the capacity of such technology systems to provide engineers with the ability to also predict project cost and performance, based on different design solutions.

BIM is today earning an increasing appreciation in the construction industry (Smith, 2014). Cost estimations based on BIM are widely recognized in research studies and literature (Kim et al., 2013). Yin and Qian (2013) conclude that by developing project cost management, based on BIM, it will be possible to improve the efficiency, quality and profits of the construction industry significantly. The research results are based upon a comparison between methods for traditional cost management and cost management based on BIM technology. Moreover, it is indicated that new methods, based on BIM will become an important business tool for the construction industry (Yin and Qian, 2013). Eastman et al. (2011) conclude that the development of BIM is going towards a scenario in which clients demand the use of BIM in their projects. Further, he sees a future where improved cost estimates with BIM as a basis leads to better decision-making during design and less waste during construction (Eastman et al., 2011).

Cost estimations based on data from BIM models are among the recent and most common methods for construction projects. Information from BIM models can be collected even from early stages of modelling. Most BIM tools today offer features, which enable extraction of quantities and building component properties. Through these, data can be exported to a spread sheet or external database for cost estimation (Eastman et al., 2011). However, the level of detail and accuracy of the BIM models can affect the ability to effectively use it as a basis for cost estimation. In a US study performed by Sattineni and Bradford (2011), one finding included: the percentage of occasions, when all necessary information needed for performing quantity take-off was included in the BIM model (sent by the architects), was concluded to be 15 percent. In another study conducted by Kim et al. (2013), the accuracy of cost

estimations based on BIM in the design phase was analysed. Some interesting findings were made. The main cause of error between the BIM-based quantity take-off and the actual quantity was created due to overlap of building elements (Kim et al., 2013).

5D BIM is an expression frequently heard in recent years in the industry, which enables the instant generation of cost budgets and genetic financial representations of the model against time (Smith, 2014). However, as described by the software program VICO (2016), which provides 5D BIM:

"a software program is no substitute for good planning and estimating skills - there is no easy button to get the right answer."

According to Eastman et al. (2011), the only commercially available tool today, which supports the conceptual design phase is DProfiler, which enables a rapid composition of a 3D model and generation of a cost estimate. The initial aim of DProfiler was to support fast exploration of different design options for the architectural practice. As the model is built in the program, real-time instant feedback on data such as cost, energy, lifecycle, cut and fill, and schedule is given (Eastman et al., 2011).

According to Sattineni and Bradford (2011), new estimators need one to two months of experience and training within BIM before the company will save time and costs on the project. Further, it is highlighted that many contracts are signed before design is complete, meaning the cost is conceptually estimated, which hinders the feasibility of estimating with a detailed BIM model. Additionally, it is stated that cost estimating is currently a time consuming process requiring large expertise. They state that the benefits of the BIM based cost estimations justify the risks involved in the transition to model-based estimating. Out of the participants in their study; who consisted of owners, vice presidents, BIM managers, BIM engineers, estimators and architects; 48 percent said that BIM had decreased the time amount needed for cost estimation. Further, 69 percent said that BIM had improved the quality of estimating (Sattineni and Bradford, 2011).

2.6 Implementation management

Implementation of new ideas and practices are considered essential for an organization in order to remain competitive in a changing business environment (Chinowsky, 2008). However, introduction of improved or completely new processes is a challenge for organizations of all types and sizes (Chinowsky, 2008). If new practices in cost estimation processes within an architect organization are to be implemented, such as introduction of new estimating software or development of existing methods or expertise, there are factors that are important to consider. In this chapter, implementation barriers and challenges as well as a framework for implementation is further presented.

2.6.1 Implementation barriers and challenges

As concluded by Poirier et al. (2015) Small and Medium Sized Enterprises (SME's) are bad at implementing innovations in their organisations. SME's stand for

enterprises with total number of employees less than 250 and with a turnover up to 50M EUR (European Commission, 2014). In the study by Poirier et al. (2015), the following factors were found to mediate the adoption and implementation process: the industry context, the institutional context, the organisational context, and the project context. These findings came from their case study of a mechanical contracting SME adopting and implementing BIM. The practical implications of their research is concluded through emphasising on: the need for clear policy at the industry level to guide the deployment of matter; and; the importance of a strategic approach to the adoption and implementation process at the organisational level.

Challenges related to implementation processes can be many and meet all types of organizations. Chinowsky (2008) mentions market demands, organizational culture, competition and workforce demographics as aspects contributing to these challenges. In the study by Chinowsky (2008), a survey was conducted in order to identify the main barriers encountered by organizations in implementation efforts. First, the largest barrier was found to be the culture and people of the organization. More specifically, convincing people to adopt the new or improved practices was considered a challenge. Second, the difficulty in expanding a new practice from one single group to other groups in the organization was pointed out. Emphasizing that it can rather be at a certain stage of the implementation process one could expect the largest challenges to be faced. Chinowsky (2008) also mentions reluctance by management to provide resources necessary for change as one factor. Furthermore, it is concluded that the responses such as those mentioned can differ from organization to organization, and that no organization should enter an implementation process without being aware of these potential responses (Chinowsky, 2008).

2.6.2 Implementation framework

Many frameworks and models for successful implementation in organizations have been presented in research throughout the years. A synthesis of the later is presented by Meyers et al. (2012) of critical steps in the implementation process based on a number of 25 previous research “how-to” frameworks (published since 2011 and related to using innovations in new settings). This synthesis was presented through the following conceptual model:

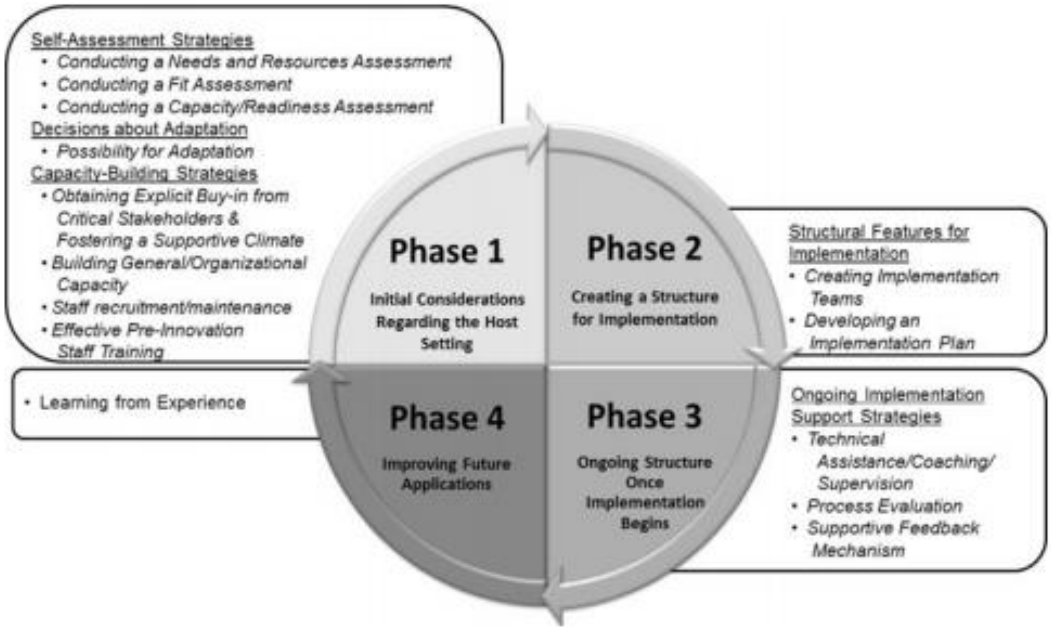

Figure 2.6 Dynamic interplay among the critical steps of the implementation (Meyers et al., 2012, p.475)

The arrows connecting each phase intend to propose that the steps in each of the phases should be continuously addressed throughout the implementation process. Meyers et al. (2012) argue that this conceptual model is applicable regardless type of innovation implementation and that it thus can offer guidance to organizations within many different fields in achieving successful implementation.

2.7 Summary of theoretical framework

This section aims to summarize the most relevant information from the literature review that is of interest for this case study. In addition, theory will be recalled in the discussion part of this thesis in order to relate it to the findings from the case study.

Burr and Jones (2010, p.126) summarize the current role of the architect as "*one who functions as the creator of the building's design*". However, it is argued that the role of the architect is in a new infancy, trying to find its new place in a constantly evolving industry (Burr and Jones, 2010). It is concluded that the role of the Swedish architect is differentiating from that abroad, even in comparison to the neighbouring countries of Denmark, Norway and Finland. The Swedish architects can be seen to have a narrower role in later project stages (Bröchner et al., 2002).

It is stated by Eastman et al. (2011) that in traditional construction projects (Design-Bid-Build), cost estimations are usually done by several actors, such as the project owner and the main contractors around bidding stage. Thus, not by the architect. Dell'Isola et al. (2002) describe from a US perspective the architect as a leader and manager of the design process, and also as one expected to take on a leadership role in cost management. However, it is expressed that not much have been done in order to improve the architect's capabilities in cost management and estimating techniques (Dell'Isola et al., 2002). Theory further brings up factors that can impact on early cost

estimations. A project's characteristics such as contract form impact on how cost estimations are done and where the role of the cost estimator is situated.

Cost estimation is in the context of this case study been defined to include the costs directly connected to the construction phase of a project; which according to Braganca et al. (2014) can be defined as including all costs from construction start to finish, such as costs of acquiring materials, costs of construction equipment, and costs of manpower. The purpose of early cost estimation, more specifically in the conceptual phase of a project, is by Eastman et al. (2011) argued to be done in order to compare and contrast the economic effect of different design concepts. In addition, several values of early cost estimations are outlined in theory. Sundaram (2008) and Ahiaga-Dagbui and Smith (2014) state that the ability to influence final costs is far greater in early project stages than in later. Braganca et al. (2014) argue that the impact of project changes in the early stages have less economic effect comparable to changes being made in later stages. According to Sundaram (2008), the main values of implementing efficient cost management at conceptual stage can be summarized as: ensuring the owner that there will be no budget overruns, that the project is completed to required scope and meets the owner's objectives as well as minimizing the risk of cost overrun. On the other hand, a number of challenges are presented as well, most of which can be seen linked to the uncertainty and scarce information of projects at early stages (Ahiaga-Dagbui and Smith, 2014).

A number of methods for estimating project costs are outlined in theory. Sattineni and Bradford (2011) state that cost estimation is currently a time consuming process, requiring large expertise. The traditional way is based on 2D drawings from which quantities are taken (Kim et al., 2013). However, Eastman et al. (2011) state that this way of performing cost estimations are both time consuming and requires extensive effort. Another method presented is the Case Based Reasoning (CBR) method. It is based on previous cases and utilizes the knowledge gained from previous experience. In that sense, the CBR method can be argued to work similarly to that of an experienced estimator by - using knowledge from previous experience in order to solve reoccurring issues (Ji et.al., 2011). However, the method requires a large database including previous cost calculations (Zima, 2015). Further, cost estimation based on quantity data from BIM-models is among the recent and most common methods for construction projects (Yin and Qian, 2013). Information such as quantity and building component properties from BIM models can be collected even from early stages of modelling (Eastman et al., 2011). It is concluded to be large benefits with BIM-based cost estimations in terms of time savings and improved quality of estimations (Sattineni and Bradford, 2011). However, it requires detail and accuracy of the BIM model. Kim et al., (2013) conclude one common cause of error between the BIM-based quantity take-off and actual quantity to be created due to overlaps of elements.

Implementation of new practices is considered essential for an organization in order to stay competitive in a changing business environment. However, introduction of improved or completely new processes is a challenge for organizations, irrespective of type and size of the organization. Challenges can be summarized to include: market demands, organizational culture, competition and reluctance of resources provided by management. It is underlined that no organization should enter an implementation process without being aware of potential challenges and barriers for that particular

context (Chinowsky, 2008). A conceptual model of the critical steps for an implementation process is presented by Meyers et al. (2012). Four main phases are outlined and the steps in each phase are suggested to continuously be addressed during the entire implementation process (Meyers et al., 2012).

3 Research Methodology

This chapter describes and discusses the type of research approach and design that have been used for this study as well as methods that have been adopted for data collection and analysis. Further, ethical considerations and how they have been addressed in this research are outlined. Lastly, the validity and reliability of this research are discussed.

3.1 Research approach and design

The research strategy for this dissertation is taking on a qualitative approach. Qualitative research stresses the understanding of the social world through an examination of the perception that individuals have on their own social environment. Therefore, qualitative research emphasises words rather than quantification in both collection and analysis of data (Bryman, 2012).

Further, an abductive research approach or, in other words, systematic combining has been applied for this thesis work. In order to justify that choice of research approach, a brief comparison between that and the inductive and deductive research approach is relevant. According to Bryman (2012), the deductive research approach appears very linear in terms of that one step of the research follows the other, in a very logical and clear way. The deductive approach and the relation between theory and research can be described as: theory is collected, and observations and findings are collected in order to test whether that theory is valid or not. On the contrary, in the inductive research approach, theory is rather the outcome of research (Bryman, 2012). Dubois and Gadde (2002) propose a third research approach: systematic combining - inspired by what is defined as abduction by Peirce (1931) and Kirkeby (1994). In that context, abduction is described as dealing with the investigation of the relationship between "everyday language and concepts" (Dubois and Gadde, 2002, p.555). Further, it is described as similar to the inductive research approach (Dubois and Gadde, 2002). According to Saldana (2011) inductive inferences are plausible. It includes the process of searching for a reason and the most likely explanation for explored patterns in research, from a range of possibilities (Saldana, 2011). Further, as explained by Bryman (2012, p.26), "the process of induction involves drawing generalizable inferences out of observations". However, it is argued that the abductive research approach rely more on theory, than what the inductive approach does (Dubois and Gadde, 2002). It is by Dubois and Gadde (2002) suggested that by investing in theory, the explanatory power of case studies increases. In addition, criticism is raised towards most textbooks on research methodology, in terms of that they rarely consider the opportunities by an intertwined research process. Case studies tend to be described as a linear process (Dubois and Gadde, 2002). Systematic combining or abduction, however, can be defined as an integrated approach. It can be described as having the researcher going "back and forth" between the different research activities and thereby between empirical observations and theory (Dubois and Gadde, 2002).

The preliminary analytical framework consists of preconceptions, and is further developed based on what is found through analysis and interpretation of the empirical data collected. The theoretical framework directs the need for empirical data and vice versa, the empirical data might result in issues that need redirection of current

theoretical framework either by expansion of existing theory or application of new theory models. To conclude, theory is complementing the understanding of the empirical data and vice versa. This is what is referred to as systematic combining (Dubois and Gadde, 2002).

A literature review has been carried out initially in order to establish a theoretical background to the subject of research. Furthermore, the literature review has contributed to the finding of current gap in research and therefore an area of interest for empirical study. The foundation to the preliminary theoretical framework of this research has been established from the beginning. However, the chapter has been revised along the way in order to better connect and relate to the findings of the empirical data. Further, the semi-structured interviews conducted in this study have raised new aspects and areas along the way that have been of interest to go back and review in theory. Research questions have been revisited and specified along the study process, while new insights have been gained within the subject of research. Additionally, there has been an interplay between the interpretation of data and theorizing, on the one hand, and data collection, on the other. Dubois and Gadde (2002) highlight this as one major difference comparable to both inductive and deductive research approach. Studies relying on abduction modify the original framework successively during the research process (Dubois and Gadde, 2002). In this subject of study, there is not extensive theory or obvious theoretical models to test or question. It can be argued to be explorative in its style. Dubois and Gadde (2002) argue the abductive research approach to be successfully applicable if the researcher's objective is to discover new things – new relationships. The abductive approach is about development of theoretical models, rather than confirmation of existing models (Dubois and Gadde, 2002). The research approach of this thesis work can thus be argued to have followed the research pattern illustrated by Dubois and Gadde (2002) as systematic combining, see Figure 3.1. This approach can be described as having consisted of two main research activities: matching and direction and redirection. Matching is about going back and forth between framework, data and analysis. That is, back and forth between theory and reality. Direction and redirection of a study deals with different sources of data and methods for data collection (Dubois and Gadde, 2002).

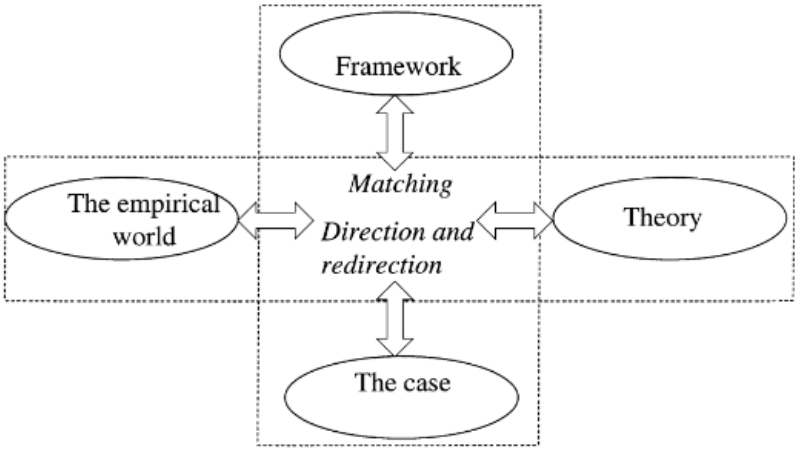

Figure 3.1 Systematic combining/abductive approach (Dubois and Gadde, 2002, p.555)

3.1.1 Case study design

A case study can be described as involving a detailed analysis of a single case, an organization. Further, a case study focuses on the complexity and unique nature of the particular case in question (Bryman, 2012). Unlike studies that examine a broad number of settings, a case study rather provides an in-depth examination. Therefore, criticism can be raised against a case study's potential generalizability and transferability (Saldana, 2011). Nevertheless, based on the results of this research, suggestions or inferences will be drawn from how the case speaks to a broader context. The single project-based organization, which constitutes the case study in this thesis is an architectural firm with about one hundred employees situated in Gothenburg, Sweden. The organization has been chosen based on being one of the larger architectural firms in Sweden. In addition, in the organization BIM models are already from sketch stage being developed as part of the work process for each project, which makes it suitable as a case for the specific area of research.

3.2 Data collection method

A qualitative research strategy commonly includes variability in data collection methods, such as using interviews and observation as research methods (Bryman, 2012). The reasons for data being gathered from a number of sources are several. First, it will provide a wider spectrum of diverse perspectives that can be presented and analysed. Secondly, the limitations of one data collection method can be addressed by application of an additional method. The limitations of participant observation can e.g. be compensated by interviews with the people included for observation (Bryman, 2012). In this case study, methods used for data collection are secondary data, and interviews, which is further described in the sections below.

3.2.1 Secondary data

Secondary data from the company have been used in order to summarize parts of the findings for this research paper. More detailed, documents have provided a basis for description of the case company's organizational structure.

3.2.2 Unstructured interviews

According to Saldana (2011), the research topic, purpose and research questions of a study normally form a basis for the questions asked during an interview. However, improvised conversation can also generate information for further inquiry. Further, interviews can therefore range from highly structured to unstructured (Saldana, 2011). In order to early on in this research process understand the context for investigation, unstructured interviews have been carried out with two people at the case company. The purpose has been to give the interviewees an opportunity to describe freely, based on experience, the context and problem justification for this research study. These occasions for interviews have been rather spontaneous and have not followed any particular agenda.

3.2.3 Semi-structured interviews

This study has to a large extent included semi-structured interviews as research method. In the semi-structured interview form, questions are prepared in advance and fairly specific topics are aimed to be covered. However, the goal is to let the interviewee give relatively free descriptions in order to understand what the interviewee views as important for the subject. Questions asked do not have to follow a particular order and questions that have not been included in the prepared interview guide may be added as the interviewer picks up on things mentioned by the interviewee (Bryman, 2012).

A total of eleven interviews have been conducted in this study. The interviews have been semi-structured and the interview process thereby flexible. The purpose was to understand the subject from the experienced reality of the interviewee's own perspectives. Interview questions have been derived from the research questions presented in Chapter 1 and can be divided into the following subject areas:

> i) Firstly, to gain understanding of if and how costs are discussed in the case firm's projects today.
>
> ii) Secondly, to get insight in the current work process in early design phase and the application of BIM on projects.
>
> iii) Thirdly, to investigate potential values and challenges of an early cost estimation, as well as to recognize the role that BIM can constitute in this context.

Interviewee Selection

Respondents for interviews have been chosen on purpose rather than on random basis. Seven responsible architects for different divisions or so-called studios in the organization have been selected for interviews. They represented in total 6 different studios and thus market areas in the company. Their extent of experience and involvement on several projects are considered to most probably mean better insight into the subject of research and into current work processes within the organization. Further, interviews have provided a base for data collection on how the architects work from an early design phase and make use of BIM today. The duration of the interviews has been approximately one hour, including eighteen questions; see interview form in Appendix I. Interviews have been carried out during a period of approximately 4 weeks, depending on the convenience of the participants. The interviews have been carried out in the case firm's Gothenburg office.

For the purpose of discovering the current level of BIM usage in the organization, one of the responsible BIM managers, who is also an architect has been interviewed. This interview was conducted initially, before the remaining architects were interviewed. The same interview form has been used, with an additional number of questions related to BIM, see Appendix I. Further, two employees working at the division of project management have been interviewed. The selected project managers are involved in internal and external projects, and are therefore considered to have another perspective to the initial phase of projects. It has been of interest to study potential differences in their role, compared to the role of the architects. Moreover, it

has been of interest to identify how knowledge of costs is distributed within the case company and additionally to which extent it is held in-house.

Interviews have also been carried out with two client parties, currently connected to the case company. This has been of interest in order to gain the opposite perspective concerning the potential value of cost estimation and increased cost awareness at an early design phase by the architect. In addition, it has been of interest to investigate the clients' work process in terms of when cost estimations are done, who takes on the role of cost estimator and based on what information calculations are done. Client interviews have been conducted in order to be able to compare and contrast the matter of subject from different perspectives and thereby increase credibility of this research. The duration of the client interviews has been approximately one hour each and included sixteen questions. The question form used for client interviews can be found in Appendix II.

Figure 3.2 Illustration of the interviewee selection for the case study

Interview Transcription
Interviews have been audio-recorded and transcribed. Recording and transcription of research material has allowed repeated and more thorough examination of *what* and *how* things have been revealed (Bryman, 2012). Further, it has enabled secondary analysis of the data collected and eased the process of coding and categorizing (Saldana, 2011).

3.3 Data analysis

Open coding and categorizing have been used in order to analyse the transcribed interview material. Kvale and Brinkmann (2014, p.241) refer to Strauss and Corbin's (1990:61) definition of open coding as "a process where data are broken down, examined, compared, conceptualized and categorized". Further, categorizing is considered to be developed from the coding process as a purpose to easier compare and contrast data. Categorizing can be illustrated as tables or figures of information (Kvale and Brinkmann, 2014). Descriptive, value and themes coding are used in order to process and detect patterns in data material (Saldana, 2011). For this research data,

words and phrases have been selected as codes based on either that they seem to stand out significantly or that they are summative of what has been said in several interviews. Further, opinions that seem to be contradictory to one another have been highlighted. Data have constantly been analysed, which has resulted in further investigation and collection of new data. Important to notify is that both coding and categorizing is dependent on the interpretations of the researcher, and on the analyst's thinking process as is the case for this study (Saldana, 2011).

3.4 Research reliability and validity

Reliability and validity are important criteria in order to establish and assess the quality of a research. In order to ensure reliability and validity of this qualitative research, the following proposed criteria by Guba and Lincoln (1994) have been addressed (Bryman, 2012, p.273):

Credibility
Respondent validation has been used to some extent in order to ensure that there is a good correspondence between findings and the perspectives of the research participants. Respondent validation is a process whereby the researcher provides the people on whom he or she has conducted research with information of the findings (Bryman, 2012). Findings and data material concerning the organization's work process in early design phase, and the organizational use of BIM have been confirmed by two employees at the company that have a leading role within the areas of expertise. Further, a shorter informative presentation has been held at a seminar at the case company before the results of this research have been published. The seminar has enabled the employees to ask questions, and raise any concerns regarding findings. Multiple data collection methods increase the credibility and trustworthiness of the study e.g. through what is known as *triangulation* - generally the use of three different viewpoints. Further, it entails the use of more than one method or source of data collection method (Saldana, 2011). See Section 3.2 for different data collection methods, and interviewee selection for different sources and viewpoints.

Transferability
The issue of transferability is one common criticism against qualitative research. Transferability refers to whether findings hold in another context than that specified for the case study. In order to address this issue, it is suggested that a thick description of the context is done. It is further argued that this will enable the reader to make the judgement of the possibility of transferability to another milieu (Bryman, 2012). A thorough description of the case and its context is presented in Chapter 4.

Dependability
Dependability refers to the trustworthiness of a research (Bryman, 2012). In order to ensure trustworthiness of this research complete records have been saved of all phases of the research process, including problem formulation, interview transcriptions, research participants and their consent, fieldwork notes as well as data analysis and findings. Further, as part of this research process peers have acted as auditors, and reviewed the work process as well as evaluated that proper procedures have been followed.

Confirmability

Confirmability refers to the objectivity of a research. Complete objectivity is difficult in social research, however, the researcher should avoid personal values and beliefs to interfere with the conduct of research (Bryman, 2012). Respondent validation and the use of more than one source and method of data collection can be argued to ensure that this research is conducted in good faith. The latter enables different perspectives on one and the same issue and avoid personal value and belief to influence findings.

4 Case company

A case study provides the basis for this research. This chapter will give a deeper description of the case company; its current structure, work processes and practices.

The case company was first founded in 1980 and is today one of the larger architectural firms in Sweden with offices in Stockholm, Gothenburg, Malmö and Buenos Aires. The Gothenburg office where this study is carried out holds approximately 150 employees of different educational and personal backgrounds. The firm is divided into different "Studios" specializing in certain architectural market areas. The company provides services in the areas of: urban planning; residential; commerce; industry; education; sport and leisure; cultural environments; healthcare; interiors; professional kitchen; and landscape. Further, the company holds departments in visualization and project management. The project management department consists of eight people and works with both internal and external projects. The project management department does not take on all the firm's in-house projects, though they try to do these projects when possible.

The case firm has a large range of clients, both private and public. Towards clients, the firm works in majority with Cost Reimbursable Contracts, which can be described as work/hour-based payment. Also Framework Agreements are used, where the firm and client signs on a collaboration lasting for a couple of years or longer. Further, the firm is involved in projects of the type Design Build and Design Bid Build but also competitions. In addition, the firm participates in approximately ten to fifteen architectural competitions per year. Historically, only a few of the competitions have been public, while most of the them have been "prequalified competitions", meaning the firm is chosen as one among a few architectural offices invited to compete for the project. Additionally, Partnering is a context in which the firm is often working.

The firm is a part of the organization *BIM Alliance*, a sector-driven, non-profit organization in Sweden. In addition, the firm is one of the main actors in the *BIM management group* through CMB (Centre for Management of the Built Environment, Chalmers) - a long-term collaboration between Chalmers University of Technology and the Swedish built environment sector.

5 Findings and Analysis

In this chapter, the case findings including analysis will be presented. The case firm and respondents' views on costs and early cost estimates are brought forward. Further, the identified values and challenges of early cost estimations are presented. Following, the client perspective is presented. Finally, values and challenges from both the architects' and clients' perspectives are summarized.

5.1 The case company perspective

The case organization has prior to this study expressed their interest in developing the general early cost awareness and further an interest in being able to perform cost estimates of projects at an early stage. Further, also in methods for doing so in which case it is speculated that information provided in available BIM models can support. To the question: "How often does it happen that you must compromise on architectural values after finished proposal documents in projects because of costs?" all of the architect respondents answered that it happens in basically every project. One of the architects expressed:

"I am certain that we compromise on architectural values almost in every project. It is rarely that everything ends up the exact way as planned, and usually it is due to other cheaper solutions available"

(Architect)

5.1.1 Current work process in early design phase

How the early design phase is carried out can vary and depend on factors such as the client, project type and contract form. The firm is as mentioned involved in a wide range of projects. What in the Swedish industry can be assimilated to as Design Build is one of the more common procurement methods in which the case firm is involved. Further, the firm works in projects of Design Bid Build character, which is the more traditional type of contract form. Design Bid Build projects means that the architect have responsibility and draws up until the final project suggestion, comparable to Design Build contract form where the contractor takes over earlier. Further, partnering as collaborative method is often used and is becoming more common among the firm's projects. Partnering projects generally start by the client contacting a contractor, before any sketch has developed for the considered project. In turn, the contractor turns to potential architects. Seen from that perspective, the contractor can then be considered as a client to the architect.

The early design phase was not pointed out during interviews as differing remarkably between Design Bid Build and Design Build. However, some of the respondents pointed out the fact that the work process and thus also the early design phase can depend on the ways and personality of the client (a role that in the Design Build contract case is undertaken by the contractor). Thus, the client and their level of expertise can largely influence the process. The Partnering project process was however found to be more distinctive in the early design phase. In Partnering, a close collaboration with the contractor, consultants and sometimes even the client exists directly from project start. In many partnering projects the case firm works in so called "project studios" which includes all disciplines and actors gather in full day

meetings once a week from an early project stage, and do so continuously throughout the design process, to mutually collaborate and agree on the best solutions for the project. As pointed out in interviews, the constellation enables the whole team to work creatively and towards a common goal, rather than against each other. This aspect has been highlighted during interviews both by the architects, the client perspective as well as the contractor. Notable is that the partnering context can look somehow different depending on project and the contractor.

The BIM process
At the case company, BIM models are already being developed as part of the work process for each project. This is described by the case firm as "a given choice" in order to have a smooth, clear, and inspiring project process. The only 3D modelling tool, which is used at the case company today, and has been since the early 2000's is Archicad. Generally, all projects of the case firm are designed in 3D, except for in rare cases when the client demands 2D drawings. The majority of projects thus start in practically the same way. Generally, in the early design phase, the architects use what is referred to as "zones" in Archicad. Thereby, what is an early sketch will be illustrated as a 3D-volume, where walls and ceilings are included. In other words, areas of different types of elements are therefore easy to summarize at an early stage such as total area of walls, floor etc. There is according to most of the respondents a decent lowest level skill of 3D and BIM modelling within the firm, while there are a few employees really good at it. The studio of project management does not work with BIM. However, it is present in projects that they are involved in.

The role that BIM plays in the design process and early design phase depends largely on the client, but also as pointed out by a couple of the interview respondents, the firm employees themselves. According to the case firm's BIM manager, BIM by definition can mean everything from making drawings and sections with the help of a BIM tool, to coordination and base for cost estimates, etc. However, BIM for the case company can be summarized to mean information loaded 3D-models. In projects, the firm always tries to determine as early as possible, which level of BIM that should be used, the aim and purpose of the model and what is to be achieved for that particular project. In relation to this, it was stated that:

> *"It is rarely made clear in the beginning of a project, either, but we just draw and sketch in the beginning. So every project has the potential to become a major BIM project."*
>
> (Architect)

During the whole design phase, the BIM model is processed and controlled, so that the information to be delivered to the client or contractor (e.g. quantity data for cost estimates) is correct. There is currently an internal BIM education through which the case firm aims to increase the general knowledge within BIM.

5.1.2 Current processes for cost estimation

As previously mentioned, the case company holds expertise within several fields. However, the role of a calculator is not an in-house expertise, but instead this work-task is undertaken by the client, the contractor, a project manager (at the client side), or handed over to consultants (an external project manager representing the client).

Cost estimations can be seen performed by different actors depending on where in the project process they are done. One of the project managers at the case firm describes it commonly to be initially the project manager's task to do a first cost estimation. However, depending on the project and its complexity, a more detailed calculation might be necessary in which case a consultant is hired. If it is a partnering work constellation, early cost estimations and more detailed calculations are generally not performed by more than one party. In this case it is rather the contractor that is involved earlier in the project process.

Cost estimations are as described normally done more than one time during a project's design, and are often based on design documents created and sent by the case firm. The maturity in BIM usage is said to be unevenly spread among the different clients and contractors. Some of the interview respondents mentioned that it is still common in projects that the calculator asks for 2D drawings or PDF's with quantities as basis for estimates instead of using quantity take-off directly from existing BIM-models. In relation to the statement first presented in this chapter concerning the compromises that are made in projects later stages due to costs, it was expressed that even though the documents sent as basis for estimates are not always that extensive, it is still something that has been "completed" and then needs to be re-made. However, another respondent stated that consequences in terms of cuts are not always bad, since they lead to more iteration and in the end possibly to an even better result. The cost estimation process will be further described in Section 5.2 from the client (and contractor) perspective.

5.1.3 Current discussion of costs in projects

In the firm's projects today production costs are said to be discussed by the architects from an early stage but mainly together with the client or the contractor rather than internally. As expressed by one of the architect respondents, the costs that are discussed *internally* within the case firm in early stages of projects are so in a general manner, e.g. what is believed to be reasonable in the project at hand based on experience.

The type of cost factors that are discussed mainly depends on where in the project process they are brought up. In the early design and conceptual stages, it is mainly the gross floor space/area, which is in focus. Further, the shape of the building, number of stairwells, numbers of different types of windows etc. are aspects largely affecting the building cost. Moreover, it is aspects such as choice of structure system and design solutions as well as the even more detailed aspect of material choices. Some of the respondents also mentioned costs in a broader perspective, in terms of life cycle costs, costs for building maintenance and energy performance to be important to consider at early stage.

From the case firm's project manager perspective, having the representative role of the client, costs are usually discussed from the very start of a project and brought up as one of the most important factors for the client. However, this can also vary depending on the project objectives. For some clients, keeping the project budget is the single most important aspect; as for others it is the architectural design. In addition, the level of project responsibility that is given to the project manager also depends on client's requests for that certain project. Costs are expressed by the project managers to be discussed constantly with the client throughout the project process,

and is said to be one of the main objectives - to steer project costs in the right direction towards the budget given. One of the project managers explain that the most important project material they, as an architectural firm, develop is the first pre-study or sketch that makes the architect think about how complex the project at hand will be. Further, it is that first sketch that will provide the base for how efficient the building's area is going to be developed, which further affects the project's economy. However, as of today, the largest focus on costs in the case firm's projects is stated to be in later more detailed stages of design.

Most respondents said that some clue of as to construction and material costs exist among the firm's employees, whilst the level of detailed knowledge is low. It was also found that the extent to which costs are discussed can vary in the firm's departments and projects, and depend on e.g. what kind of prerequisites the project has, what type of client that is involved, the experience and level of cost awareness that the architects which are involved have, etc. Some interviewees also expressed that though feedback concerning budget often is received from the client or contractor, it is generally not of the character that costs are specified. Instead, it is more in the form of directives saying that certain cuts and changes in the design need to be made. However, in partnering projects, it was said that clearer feedback on budget and costs in the design phase are generally given. However, the following was also said regarding these type of projects:

"DB here leaves much room for the contractor to build based on their own experience... but yes, to a certain point we are involved but then there aren't so many questions raised but instead they solve it and not always in the way expected."
(Architect/BIM Manager)

One architect expressed that looking back, and compared to the traditional procurement method of Design Bid Build, costs have not really been a focus topic until construction documents have been handed over to the contractor who makes a first cost estimation. Further, in Design-Build projects that make up for most of the company's projects, the possibilities of control and follow-up on project outcomes are limited. However, how involved the architect becomes in discussions varies from project to project, but also depending on the organization and personalities with whom they are working. In general, the architects lose their involvement as the building actor most of the time prefers full responsibility during production. In most projects some of the architectural values are traded for more economic beneficial solutions. In the partnering constellation, the contractor contributes with their expertise within project construction costs.

5.1.4 Views on cost estimates in early design phase

From interviews, it was found that costs today are discussed in a general way but not in detail, and an overall perception among the architects is that they can improve their skills regarding costs. One of the interviewed stated the current challenge of production costs as rather raising more questions than answers. That when being in a situation of weighing different design choices, more support and knowledge considering costs would be needed.

It is further stated that individual knowledge within the area of cost has mainly been gained based on participating on projects, meaning that the level of knowledge also

differs depending on experience. Although, insight into the discussion of costs are gained throughout the project process through interaction with client and on occasions the building actor, seldom does information of the actual final project costs reach the architect. Respondents stated that architects in general seem to be poor at asking for the final project costs, and are thus poor in this regard at learning from previous projects. Further notable is that follow-up and feedback on final production costs of projects seem to be low within the firm. Moreover, it was stated by one respondent that either this feedback is not given or it is not asked for.

There were mixed views among the interviewed architects about what could be included in early cost estimates. Some saw complete project cost estimations as a possibility, while others were more focused on increasing the overall cost awareness. This is not really surprising since the architect respondents have different experience and work with different kinds of projects, some working on a larger scale with e.g. urban planning and others on a smaller scale with residences etc. Most discussed the construction costs, which have been defined in theory, see Chapter 2 of this dissertation. Also factors such as life cycle costs and maintenance costs were mentioned to be important to include and not loose at this stage. That it is a matter of weighing the life expectancy of e.g. material against costs to buy. Further, it was said that, although life cycle costs would not necessarily be included in an early estimation of production costs, construction cost estimates are of value and can help in defending and justifying choices argued for. What to base these construction cost estimates on was speculated as the gross floor area (BTA) and the outer shell. One architect's experience-based perception was that area efficiency is in many cases more of a cost saver than choices of materials or details. Further, the large parameters and major choices such as type of structure, the building shape, and number of floors were parts, which the respondents wanted to be able to estimate in terms of costs. It was also speculated that the estimate in this stage could probably give indications on costs of certain elements and parts of a building as well as give an average cost per square meter for the whole building. On the more detailed level it was also mentioned by some respondents that it would be good to be able to see an indication on certain material expenses and be able to compare possible choices. The different views on the cost aspect among the case firm respondents can be summarized to include the following:

1. Increasing overall cost awareness, or
2. doing complete project cost estimates, or
3. performing architectural part-estimates

Conclusively, most of the case firm respondents seem to think about potential in-house cost estimations as total construction cost estimations as well as estimates for parts of the building (such as for comparing costs of different design solutions). Moreover, that such cost estimations are considered for internal purposes at the moment and thus not for the purpose of taking over the role of cost estimator/calculator in projects.

5.1.5 Values and challenges of early cost estimations

A recurring view among the architects on the winnings of being able to perform cost estimations was that they can become more confident and better be able to argue for the architectural objectives and values of a project. Further, it was stated that by the

latter the architects could be able to decrease the amount of cases in which architectural values need to be compromised on later in the project process due to economic considerations. In other words, it is suggested that the architects can increase their influence on the project, and concerning what should be compromised on and not. In this context, one of the architects refer to what is commonly the case on projects:

"*There have been numerous situations where some of the architectural values, in terms of design or material chosen, have been down-prioritized later on in the process due to economic reasons*"

(Architect)

An increased insight in project costs and an ability to estimate these, as pointed out by many respondents, will most probably lead to reinforced architectural qualities in the end. One of the architects clearly motivates and summarizes the value of this:

"*Today, the architect easily gets neglected during discussions. Environmental aspects, energy and economy are "hard" factors that always plays a central role in the end of a project, contributing to these shortcuts and are therefore important for us to gain control over*"

(Architect)

Shortcuts referred to in this context are the architectural ambitions that often are neglected due to other economically preferable solutions. In relation to this, one of the architects express the potential value of being able to estimate project costs to be:

"That the architectural aspects can be reinforced; that we can push through details of a project that are important for the architectural formation and end product by an increased control of the cost that certain choices or changes will include "

(Architect)

One respondent expressed the belief in that larger cost awareness or the ability to perform cost estimates would allow for an even more aesthetic design process. Additionally, some expressed that being able to perform own cost estimates could be useful when weighing different design solutions against each other.

"*A method for estimating cost early in the project process can enable our architects to compare and predict the economic effect of different design solutions, which can make it easier to motivate decisions made*"

(Architect/BIM manager)

Additionally, one respondent speculates in that it would help in identifying cost drivers early in the project process. In a broader perspective, it was also suggested that with a better background in economic aspects the architect would be able to choose and argue for sustainable economic solutions more effectively.

There was a somewhat mixed view of what new practices could mean for the design work process. Some respondents anticipated a slower work process, while others imagined it to become more efficient, arguing that smarter economical solutions could be decided on earlier. In this sense it was said that it probably would enhance both the communicational aspect and the overall satisfaction of both client and contractor in

terms of more cost efficient solutions. Also, increased credibility towards the client and contractor was repeatedly mentioned as a value and winning factor: in the means of delivering what the client is expecting without compromising or changing too much in later stages. In this context it was said that:

"It can result in a better sense of control, compared with today when we have little perception of costs"

(Architect)

"I believe it will increase the credibility of what we do, so that the customer will feel more certain of the outcome; that there will not have to be much rework or changes done later on in the project, but rather that it can end up correct from the beginning"

(Architect)

Most of the architects predict the value of early cost estimates and increased cost awareness to be biggest in Design-Build projects, with the main argument to indirectly be able to control project outcomes better. In such projects today, the architect often feels disappointment once the building is finalized, due to changes having been made by the contractor in order to decrease costs - mostly through chasing cheaper solutions. Further, it was speculated by the architects that the procurement methods Design Bid Build and Design Build will both remain. An increased number of partnering constellation projects were speculated by the respondents to be seen further on. Notable was that the majority of respondents found the winnings to be big also in the partnering context.

Some of the challenges with early cost estimations mentioned by the case firm concerned work processes. Some of the architects mentioned in the interviews that, although it is important to be aware of costs in early design stages, one should anyhow not be too steered by specific and detailed cost aspects. Further, it was argued that it could be inhibiting to be too exact in the conceptual phases of the design process. The following statement given by one of the architect interviewees can summarize this point of view:

"I may not want to be precise, I just want to draw a door, and not think about whether it is a steel door or a wooden door"

(Architect)

In relation to this it was also stated that the earlier such cost aspects are considered, the better final economic solutions for the project. Conclusively, that it should be seen as opportunity giving rather than inhibitory. In the means of becoming project estimators, and provide such project information externally towards clients or contractors, one of the architects mention that new responsibility would follow - a responsibility that currently is someone else's. So, such a work task is dependent on that the user is skilled, thorough and knows what they are doing.

5.1.6 BIM as a base for cost estimations

All respondents within the office somehow stated that they saw possibilities with BIM as base for cost estimations. The exactness and the speed were mentioned as some of its advantages. In comparison to the traditional ways of doing estimates based on 2D, where a few changes would mean that the estimate would have to be completely

remade, BIM based ones would either change simultaneously as the model is changed or be very easily and quickly updated. As concluded, to put in and extract information and quantities from the BIM model is something that can easily be done at the firm. It was stated by the firm BIM manager that many databases for costs exist today, which means that cost estimations could be done based on the information extracted from BIM and then calculated in a different software tool such as Excel. Some of the respondents also mentioned existing BIM estimating tools such as VICO (described previously in the theoretical chapter), but that the use of such so far in the Swedish industry is rare.

Some challenges concerning BIM as base for cost estimates were also pointed out during interviews. It was stated that some of the tools existing on the market today are too detailed for early design phases and would probably mean large investments in time and money in relation to the value they actually provide. Another challenge with early cost estimates predicted by several of the respondents was to determine the level of detailed information that is needed in the BIM model to be able to perform an estimate. Further, one respondent stated that "it cannot be of the character as the traditional construction estimates used today, since other construction data is missing". It was also mentioned that the level of BIM knowledge of the user within the firm could be a challenge. However, raising the BIM expertise level in the firm is a current process. Further, another interesting viewpoint concerned the use of modelling software. One respondent stated that the architectural industry is going towards a more extensive use of Autodesk Revit as applied BIM tool, and that many firms that previously worked with Archicad is changing their software program. Concerns regarded whether it could be a problem if a cost estimation program might be linked to a specific BIM tool, and then become useless if the BIM tool were to be exchanged.

Another challenge stated by one of the architects was that of a probable additional aspect to the controlling of model accuracy, which probably would be of importance to include earlier in the process than what is done today. This was brought up in both contexts of: doing internal estimates for own purposes and in sharing cost information externally with other parties such as the client. That is, in order to ensure the validity of a cost estimation based on information provided in the 3D model, a control of the correctness in building elements and quantities is necessary. The following statements underlines the above mentioned viewpoints, as well as previously discussed importance of not letting costs steer too much in the creative process:

> *"The challenge is rather to find a methodology in the modelling process for each project, and figure out what information to put into the model in order to bring out the information needed. At the same time, those work methods shall not be a hindrance to the creative design process".* Adding that, *"cost estimation should rather be an effect from the work already being made"*
>
> (Architect)

Conclusively, to find a suitable estimating tool or working method is of course crucial to make the process valuable. Furthermore, apart from seeing the possibilities with BIM as support in cost estimations and cost awareness, a couple of the architect respondents mentioned that: in order to increase cost awareness within the organization, it could be valuable to hold an experienced estimator within the company alongside educating.

5.1.7 The architect's role in the project's economic discussion

When being asked if the architect's role can change with an increased knowledge of costs, the general perception is that: an increased knowledge can provide the architects with better prerequisites to steer and control the final drawings. Another is that it can provide a basis for argumentation with client and contractor.

A couple of the employees at the case firm respond that an increased insight in economy is one factor in order to regain a previous role that the architects possessed. In this context, it is expressed that since the 60's, the architectural role can be seen to have diminished due to the Swedish million-program, and the large contractors' increased influence in the construction industry. Before that, the architect was taking on more of an expertise and guidance role throughout the project process. In addition, a couple of the architects refer to the fact that in other countries the architect usually has more influence on the project process and its outcomes, and that includes the economic responsibility, than the same profession in Sweden.

One architect expresses an interesting view: that in general architects might be given the role and influence that they deserve. Therefore, criticism should maybe not be raised towards the contractor. Further, arguing that if clients see that architects possess more knowledge, another responsibility might also be given. In addition, it is suggested that in order to receive such it might also be necessary to take on a more deliberate approach and role.

Another answer linked to the previous one is that the role of the architect could become more similar to that of the project manager - it would increase the possibility to take on a more representative role in the project. Another express that it is a wish to participate longer in the project process than what is done today. In addition, several responses include: it would increase the client's trust in the architect and raise the architect's credibility. One of the project managers at the case company state that: "there are project managers that are more focused on the economic aspects of a project rather than the final product results, which is not always beneficial". However, if the architect takes on more of a leading role in meetings during the design phase, arguing for specific project objectives and also has more of an influential role - it is more likely that those objectives will be realised. Further, it is stated that with reasonable arguments in terms of both design and economy, the architect can strengthen and possibly change its professional role.

One project manager states that in order to increase knowledge and expertise it is crucial for the architect to get the opportunity to follow projects, its processes and outcomes. Thus, not only being a part of the earlier phases up to finished documents, where the project is then handed over to other parties. This is said to be the case for some of the firm's projects and for the architectural role in general. Further, it is stated that regardless of the contract form the project ought to benefit from having the same architect from early sketches to finished building documents. In a broader perspective, it was argued that the architect could possibly contribute with qualities to our overall architectural and building environment. This in terms of a larger variety and adaption of the buildings to its particular context.

5.2 The client perspective

The clients interviewed in this study represent two parties, which the case company recently has been or currently are working with. One represents the public sector, and the other, which also can be seen as contractor, the private sector.

5.2.1 Current processes in cost estimations

The type of costs that according to the clients are discussed at early project stages can be seen to align with what was expressed by the architects: mainly the area of the building, number of floors etc. Another cost factor mentioned is the required standard of the building, and if a particular classification of the building is to be aimed for. To conclude, everything that is additional to the basic standard requisites have an impact on early project cost discussions. Another important cost parameter mentioned by both clients is building techniques and production methods. In other words, how construction is carried out practically. Further, choice of materials and suppliers can contribute to a lot of cost savings. Another aspect mentioned, in terms of making wise cost decisions is that of including a more long-term perspective such as Life Cycle Costs (LCC). Notably is, that this was expressed by the public client. Further, at early project stage it is important to possess the overall understanding of how different choices affect the project in the long run.

The early cost estimations that both client respondents produce are made based on simple key figures such as cost per square meter or cubic meter. One client identifies costs based on key indicators, experience of previous projects of similar type and specific industry literature. The same client, which represents the public sector, state that rough estimates are made in-house at early project stage, however, there is no expertise in terms of an in-house cost calculator. Further stated by this client, projects that are similar to previous ones are most of the time seen as rather easy to estimate. However, as soon as some factors are unknown or there are additional aspects of new character to be considered, it is more difficult. The more detailed calculations that are needed later in the project process are generally handed over to a consultant or the contractor. However, in this context it was stated that:

> *"The contractor is without doubt the best. As a consultant it is rare to possess the same experience. However, the contractor is constantly involved, working with this every day and they are the best in terms of making the most accurate calculations"*
>
> (Client)

The client interviewee, who acts also as contractor, has the in-house expertise of a calculator. In this case, the calculator also works as a tender engineer and carries out the firm's calculations for production. Further, the same division does project follow-ups and creates databases of experience-based project costs for the company. This client respondent roughly valued the error margins for estimating costs in early stages to be ten to fifteen percent depending on type of project, which according to them was as close as one could get at such stage. These key figures are based on their own built up project database. Data are collected from projects throughout the country. That way, by comparing similar circumstances for the project at hand with factors available, a rather close cost estimation can be estimated.

Early on in a project, template figures of area are used as a base for cost estimation. Based on this, area and plan efficiency then becomes a discussion, such as rooms and passages (corridors). The client and contractor has recently been involved in a successful partnering project together with the case company. Costs have been a main focus from the beginning in order to not reach budget overrun, and an obligation in order to proceed with the project. The partnering context has included a close cooperation from the project start, throughout the design phase and to final project. The following work approach is described in the context of this process. When details are drawn and system handlings are finished, detailed calculations are done based on the information provided in available 3D model, such as quantities. The client expresses that: "today, a heavy workload is placed on the architects and engineers in terms of classifying all elements correctly in order for the model to align with our calculation program" called Map. Quantities are then transferred directly and any changes done in the model directly affect costs. A quick recalculation can therefore easily be done. The calculation program can be described as consisting of different recipes connected to different building elements. A standard quantity is connected to each building element, which can be changed manually according to the specific project.

From the client perspective it is of general importance on four different occasions to estimate costs. However, at an early stage of a project it is of interest to estimate costs on two occasions. A first estimation is done really early, normally after a pre-study of the project. At this time, all that is included in a calculation is the estimated area and volume of the building. Further, for a public client and project, this estimation then becomes the foundation to a political decision of whether or not the project can proceed. The second cost estimation is generally done after parts of the design phase have been completed together with the architects, and when more information about the building is available. A decision of whether to go through with construction or not is made after a detailed calculation at the end of the design phase. At this point, project costs need to be almost one hundred percent correct, plus or minus five percent. Moreover, as the project proceeds calculations are made rather often, depending on how the project is considered to be most suitably approached.

5.2.2 Values and challenges of early cost estimations

One of the clients stated, as several of the architect respondents, that it is common that architectural values are compromised in projects in later stages due to costs. Thus, the winnings that the architects see in being able to reduce these cases (through an increased cost awareness or potential to perform estimations) can naturally be winnings also for clients and future users of the building. When it comes to seeing architects taking on a new role as cost estimator, the respondents' views were somewhat varying. The public client saw a potential in receiving estimates from the architects. However, it was also expressed that if this were the case today, additional control estimation would probably be done in-house anyway - expressed partly to be due to trust issues. But, it was also said that the more cost estimates one could receive, the closer to a more accurate project cost figure at an early stage one could reach. When being asked if it would be of interest to use BIM and developed 3D models also parallel for project costs, the client conclude that the more information that is available for the project the better - although, it would rather be of interest in the more detailed design phase, not the early conceptual design phase. A challenge for the

architect in such case, identified by the client, is that of finding a suitable balance for what level of information to store in the model.

The other interviewee, who also acts as a contractor, saw not surprisingly less winnings with architects providing complete cost estimates. This due to that they already hold this expertise in-house. However, the respondent concluded that an increase in cost awareness among the architects would be very much welcomed. The same interviewee identifies one challenge for the architects in making early cost estimates - the lack of base figures for production costs. In other words, the architects do not have the same access to final project costs as the contractor. Another challenge in achieving fair early cost estimations that were mentioned by the interviewee is that of soil conditions as well as the market and how that affects prices for material.

It is perceived that both client respondents generally aim to build long-term cooperation with the architects. Thus, if the architects were to increase their knowledge also in this field, possibilities for appreciation and longer cooperation between customers are large.

5.2.3 Economic factors to consider in early cost estimation

Clients conclude the architect's main strength to be floor plan/area efficiency. It is also stated from the clients' perspectives that this can be seen to have developed more over the last couple of years, that areas are more flexible and can be used for a number of purposes.

When it comes to how and what architects can do in increasing cost awareness and potentially perform cost estimates some notes were given by the client respondents. One was that detail-work is a part that can vary largely in costs depending on how they are made. Thus, a larger knowledge in detail-work among the architects is desired, including thinking about whether and how these could be easily built and installed. This to be able to minimize the time needed for craftsmanship.

5.3 Values and challenges of early cost estimation; a synthesis

The internal values identified through the case company interviews were several. One of the main findings from the interviews was that in basically all projects, architectural values were perceived as being compromised on in later project stages due to economic reasons. This fact was also expressed by one of the client interviewees. Most of the architect interviewees saw possibilities of reducing these cases if cost estimations could be performed internally and if a larger cost awareness is built up.

As concluded in Section 5.1.4 the perspective in which the architect respondents see cost estimations in relation differ. These have earlier been summarized as 1) increasing the overall cost awareness, 2) doing complete project cost estimates, and 3) performing architectural part estimates. These perspectives can further be seen to influence on the perception of potential values and challenges of early cost estimates identified by the architects and clients.

Though one of the client interviewees was positive towards the idea that they could receive trustable complete project cost estimates directly from the architects, the same also stated that the contractor is without doubt the best at performing accurate estimations today. It can thus be argued that the need and value of performing thorough construction cost estimates as a service are limited, since several actors imaginably will continue to perform estimations at other ends. Meaning double work will be performed. However, if trust is built over time this tendency might diminish. However, concluded by both client respondents that an increased *cost awareness* among the architects would be of large value.

The values can therefore be concluded to be largest internally when it comes to being able to perform cost estimations in projects. However, if the focus is on an increased cost awareness and performing cost estimates for internal purpose rather than taking over a new role and responsibility of the calculating process, more external gains were identified. This since both client interviewees stated that they would like to see an increased awareness of costs among the architects. The table 5.1 below presents the summarized findings on gains for the architectural practice based on both architect and client interviews.

Table 5.1 Potential internal vs external gains of early cost estimates among architects.

Internal gains	External gains
Confidently argue for sustainable economic solutions/architectural values	Strengthen the architect's role and influence on the project outcome
Increased architectural value/quality on finished product	Increased credibility towards client and contractor
Weigh different design choices	Increased communication/interaction/reasoning between architects and the client/contractor
Efficient work process - finding better solutions quicker	Increased client satisfaction due to more cost efficient solutions
Identify cost drivers early	

Partnering as a procurement method was by both the client side and architects in this case study forecasted to grow in numbers in the upcoming years. One interesting finding was however that this context did not decrease the perceived gains of being able to perform cost estimations and increase awareness of costs.

Many of the challenges brought up in this study were "overall" and concerned e.g. uncertainties and risks, changes in roles and processes, as well as new responsibilities

that would potentially follow. The following table summarizes the possible challenges concerning early cost estimations in the context pointed out by the interviewee respondents - both the case company themselves and clients. These challenges can be considered as "overall" in the perspective of architects performing early cost estimations.

Table 5.2 Overall challenges of early cost estimates

Overall Challenges with Early Cost Estimations	Description
Additional factor to consider in work process	New cost estimation processes were both proposed to consume extra time in the design process, but also on the contrary said to possibly simplify and speed up the process
Keep a free and creative design process	It was continuously stated that too much focus on costs in the early design phase could possibly hinder the creative process
Responsibility risks	If a new role is to be taken/service to be offered by the architects - this would mean larger carrying of responsibility and risk
Keep updated on market prices	(Mentioned by client) For what price materials and services can be bought were mentioned as challenging in early stages, since it can vary locally, cyclically etc.
Low access to final project costs	(Mentioned by client as challenging for the architect) A knowledge database including earlier projects increase the chances for accurate estimates

5.4 The impact or support of BIM in potential early cost estimations

BIM is a process where the possibilities are pretty much limitless. However, models are not being developed more than what is necessary for that particular project. The level of BIM that is applied often depends on the project and the interest of the client. It is further stated, based on the architect's point of view, that: "some (building owners or clients) argue BIM to be most beneficial for the contractor and the architect". One of the clients, although they themselves are involved in BIM projects and see the potential and value of doing so, expresses a general perception that: "clients seem a bit careful since the costs are higher to design in BIM, adding that the

overall perception is - it costs too much". However, adding that what might be missing when reasoning accordingly is the overall project winnings. From a client perspective, BIM is today mainly applied for visualization purposes. In a context and architectural organization as in this case study, where there are already set processes for how to work with BIM, it can be argued that the economic issue of extending designing and also include costs is minor.

One finding from this study was the mixed view among the architect respondents concerning what is to be included in early cost estimations and how they could be performed. Findings suggest early cost estimation to cover a range of economic variables. An effort in categorizing these can be seen in Figure 5.1 below. Some economic variables have been categorized as core factors; these are economic aspects linked to what is in focus for this research; costs directly connected to the construction phase. Further, these are also economic factors concluded to be possible to extract from a 3D modelling tool, and thereby supported by BIM. However, some important aspects of costs were considered to be harder to estimate with the help of BIM. Examples of these are the building shape and detail-work complexity, cost factors, which the contractor can be argued to have better prerequisites to estimate due to their experience. An effort in categorizing cost aspects that can be estimated and those that are more difficult to estimate with the support of BIM can be seen in Figure 5.1.

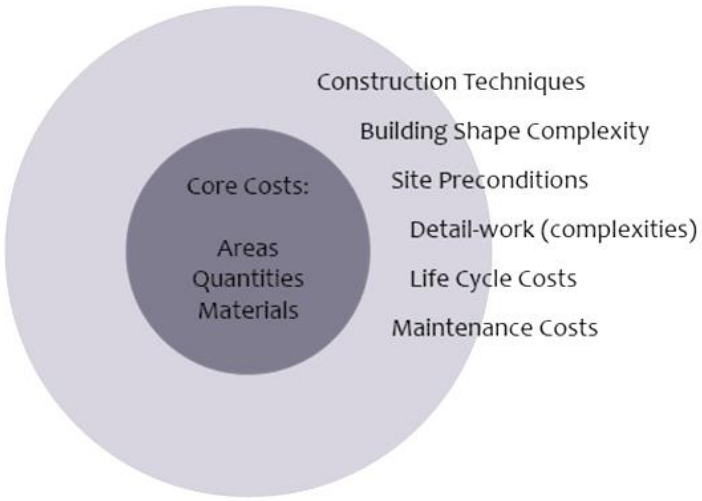

Figure 5.1 Costs discussed to be important to think about in early design stages, divided into levels of how easily they could be estimated

Most of the interviewees stated their positivity towards BIM and its potential in acting as support in early cost estimations. However, there were also many challenges identified concerning BIM in this context. The most frequently mentioned challenges was to maintain a free and creative design process, ensure the level of information needed in the model in order to perform a decent cost estimation as well as the expertise in the BIM modelling process. The following table 5.3 presents the challenges more specifically linked to BIM as base for cost estimations in this context.

Table 5.3 Potential challenges with BIM-based cost estimations

Potential challenges with BIM-based cost estimations	Description
Software investments	Some of the existing tools on the market are too detailed for early design phases. Additionally, potential future change of BIM tool could mean loss in investments
Level of program/BIM expertise needed	The level of BIM knowledge could impact on how estimations can be performed
Level of information in the model	Brought up by several respondents: the level of detail and information that is needed in the BIM model to be able to perform the estimate based on that model
Higher demand on checks and control of model	(e.g. number of elements, overlapping elements) Controlling of model accuracy would probably be more important and would probably have to be done earlier in the process than what is done today

6 Discussion

This chapter aims to evaluate the findings from the case study and compare them to the theory. The structure of the discussion chapter aims to follow that of the research questions outlined in the introduction chapter.

This thesis aimed to look at early cost estimates from the architect's perspective, with the main purpose of identifying the values and challenges with this as well as if and how BIM can impact or support in this context. As pointed out early on in this study there is a gap in research regarding cost estimation in the early design phase, and especially from an architect's point of view. In that regard, this study contributes to a new perspective within the construction cost estimation discussion.

6.1 Early cost estimates; what it could mean and include

The first part of this study set out to explore how cost estimation can be defined and what it can include at an early design stage of projects, and further specifically in the architectural practice.

Findings from this case study suggest that at an early stage of a project process, experience based figures are commonly used for cost estimations. Clients refer to template figures collected from a database built up by their firm's own performed projects or general and accessible key figures from the industry. Findings can therefore be seen to align with what is expressed in the literature review by Ji et al (2011) that solutions to a new problem is advantageously and commonly solved by gathering data from the most similar cases and adjusting them to the new case. Further, methods for cost estimations based on earlier projects, such as CBR presented in theory, see Section 2.5.2, were found to be the best in early stages of projects both according to theory and case findings. It can be argued that also the architectural practice could gain on increasing their learning from earlier projects and building their own project database, which could then be used as base in project cost estimations.

The type of cost factors that were most frequently mentioned as desirable by the architects to include in early cost estimates were those related to construction costs. However, additional cost factors were brought up, which the architects considered of importance to include for reasoning at early project stage, such as costs for maintenance and life cycle costs. These are aspects that can be seen in the broader perspective of an *increased cost awareness*.

In theory it was stated by Elfaki et al. (2014) that cost estimation is a knowledge-intensive task - depending on human professional expertise. Further, it was stated that this expertise takes years to develop (Elfaki et al, 2014). This fact easily directs the discussion towards the role of the architect, the increased interest in the economical aspect of projects and how cost estimations potentially should be undertaken in this context. Is the role of cost estimator something that can or should be undertaken by the architect? Further, how detailed these cost estimations should be. In relation to the statement by Elfaki et al. (2014), it can be argued that if one were to receive cost feedback from e.g. an estimating BIM tool without having the experience, too much trust will be put on the program, which can be risky.

Findings from case interviews conducted represent different perspectives within the firm such as the perceived value of: investing in an experienced calculator in-house, using supporting technical tools such as BIM, but also overall increasing general knowledge concerning costs. These aspects can be discussed in relation to what values it can bring to an architectural organization. That of contributing to a total project cost estimation or architectural part-estimations. Most architects argue the winnings to be large from the perspective of an increased general knowledge of costs and including internal estimations, rather than taking over the role of complete calculators. Findings suggest that BIM is widely seen among the architects as a potential support in this context.

6.2 Values and challenges of early cost estimations

The second part of this study aimed to identify potential values and challenges of project cost estimation at an early design stage from the architect's perspective.

In the literature review, Eastman et al. (2011) stated that today cost estimations are often done too late in projects, and that as a result of these not being made in the early design phase, compromises to the original design often have to be made later on in projects. This was confirmed through one of the main findings of this study: that in practically all projects, architectural values were said to be compromised in later stages of projects due to economic reasons. Thus, being able to reduce these cases can be seen as the overall largest value found for the architects, and the underlying factor to why a larger control of project costs is desired.

Findings from this case study suggest that there is a large perceived value in an *increased cost awareness* among architects. Further, findings suggest the values of architects implementing *cost estimation processes* to be several, first and foremost internally within the architectural firm but also externally, towards clients and other parties. In the earlier literature review, it was also stated that cost estimations at early design stages are done in order to determine the cost effect of certain design concepts (Eastman et al., 2011). This purpose can be seen to align with what was expressed by several respondents in this case study as a potential value for the architect organization. It can be argued that by having the possibility to perform cost estimations on certain parts of projects (previously referred to as architectural part-estimates) together with an increased cost awareness, many values can be found. For example, a certain design's high construction costs can be a deliberate choice and further justified by its low life cycle costs, e.g. its quality life expectancy or low need for maintenance. Thus argued, underlining again the importance of raising awareness of costs alongside performing part-estimates on construction costs. Additionally, findings suggest that winnings can be concluded to exist also on the broader perspective, by increasing the project cost dialogue between all parties involved on the project and leading to overall better project outcomes.

One of the main challenges of early cost estimation raised in literature is the scarce information available at an early project stage (Ahiga-Dagbui and Smith, 2014), however referring to cost estimations on the larger scale for the whole project, thus not completely comparable to the potential of architects performing part-estimates. It was further stated by Eastman et al. (2011) that early cost estimation models should provide a balance between supporting the creative thinking process and at the same time provide fast assessment and feedback. In relation to this, interviewees in this

case study raised concerns regarding that introducing new cost estimation processes could inhibit the creative thinking and design process.

Apart from already brought up aspects, several values and challenges were identified in theory and the case study when it comes to BIM as base for these cost estimations. Those are further discussed in the following chapter.

6.3 The role of BIM as support tool for early cost estimations

As concluded in the literature review, few tools for project cost estimation, which support the early design stages, exist on the market today (Eastman et al., 2011). As described in both theory and through case interviews, the ones that exist are rather suitable for later and more detailed project stages and are often complex and expensive. However, to extract quantities from BIM-models, and then export the data to a spread sheet or external database for cost estimation, as mentioned by Eastman et al. (2011), is a common procedure when doing project cost estimations. As BIM models at the case company are developed from first conceptual stage in basically all projects, the prerequisites for using BIM data as base for cost estimations are good. Further, the concerns raised in the case study regarding investments and losses if the BIM software were to be changed, are thus no problem. In this context, the BIM tool that acts as base could be replaced by another without affecting the estimating process or meaning extra costs.

Findings of this case study regarding current ways of cost estimation in the industry support the fact that information, in terms of e.g. quantities, stored in 3D BIM models generally need to be "coded" in a certain way in order to fit calculation programs available and used. Therefore, what has been wished for as a quick and efficient cost estimation, not inhibiting the design process too much, can to some extent seem contradictory to the work effort and level of information actually required in order to perform such cost estimations.

The concerns that were raised during interviews regarding the information needed in BIM to be able to perform reasonable estimations and the aspect of controlling model correctness are in line with the theoretical framework. This was underlined in the studies performed by Sattineni and Bradford (2011) and Kim et al. (2013): the importance of having enough information in the BIM model to perform fairly reasonable estimates as well as the problem with quantity errors due to overlapping elements. Further, it was stated by Sattineni and Bradford (2011) that new estimators need one to two months of experience and training within BIM before the company will save time and costs on the project. However, in cases where a large BIM expertise already have been developed among the employees, as in the case firm, it can be argued that the learning period needed probably will be reduced.

It can be argued that some of these challenges are too large when it comes to being able to perform reasonable total project cost estimates in early stages based on BIM. However, in supporting the smaller estimates, which have earlier been discussed, these challenges can be seen as possible to overcome.

6.4 Implementation management

It was argued in literature that in order to stay competitive in a changing business environment implementation of new ideas and practices are crucial for organizations (Chinowsky, 2008). This fact can be seen also through the architect respondents' views on the matter, many stating there is much to gain on the competitive market through implementing these proposed practices.

The question of whether the wide variety of automated estimating programs is really suitable for the architect profession, was raised by Dell'Isola et al. (2002). It was also found in this study that the architects saw the tools, which they knew of (BIM-based) as too complex for early stages of projects. Therefore, potential investments must be weighed against value and applicability to the architectural context and purpose in order to decide whether they are justifiable.

As mentioned by Sattineni and Bradford (2011), a major aspect that needs to be thought of in implementation of new estimating software is the confidence of the estimator using it. Additionally, that new estimators need one to two months of training experience within BIM before the company will save time and costs on the project (Sattineni and Bradford, 2011). This was confirmed through interviews, where the experience of the person performing the job was mentioned as one potential challenge. Creating a new function or additional work method within the architectural practice would thus be a challenge, as it could mean considerable investments in both time and money.

The main barriers in organization's implementation efforts identified by Chinowsky (2008) could be potential also in the case study context. The first challenge regarded the culture of the organization and getting employees on board, accepting and adopting the changes and new practices. However, it can be argued that since most employee respondents in the case company were positive towards these changes and ideas, this barrier would be reasonably small. The difference of BIM expertise was one factor mentioned by the respondents as challenging when it came to doing potential estimates based on BIM, this can be related to the second large identified challenge by Chinowsky (2008) which concerned expanding a new practice from one single group to other groups within the organization. The processes and practices implemented and learned by a certain group in first stages might thus be challenging to transfer to all parts of the organization, also in the case study context.

Poirier et al. (2015) argues that SME's, a group in which the case company is included, are bad at implementing innovations within their organizations. Thus it can be said to be more crucial for this type of organizations to have a good implementation strategy. As Meyers et al. (2012) argue their conceptual model of critical steps in implementation to be applicable to most cases and industries; it could probably be a successful support for the case company.

Furthermore, apart from seeing the possibilities with BIM as support in cost estimations and in raising cost awareness, a couple of the architect respondents mentioned that in order to increase cost awareness within the organization, it could be valuable to hold an experienced estimator within the company. This could arguably be a good idea which also goes in line with the framework presented by Poirier et al. (2015), saying that a crucial part of the first implementation stage is to have capacity-

building strategies including staff recruitment and staff training. Additionally, that in the third phase it is crucial to have ongoing implementation support strategies, which includes e.g. a supportive feedback mechanism. It can be argued that including an experienced estimator in-house could work as such a support. Further, in such case, what Sundaram (2008) state as factors for successful project cost management: a well-organized methodology and approach, team members understanding their roles and good estimating techniques applied would then apply to the context of the case company.

6.5 Change in roles and processes

Findings of this study suggest that the architects themselves and external clients see many values in an *increased cost awareness* among architects. However, if such was to be included into the architectural practice, it can be argued that this may have effects on the architectural role, as well as on other parties involved in the project process. Also as presented in the theoretical review of this study some authors have discussed specifically about the architect taking on more of the economic responsibility. Dell'Isola et al (2002) is one, saying the architect is expected to take on a leadership role in the cost management process, but at the same time arguing that not much have been done in order to improve this aspect.

It was stated in theory that the role of the architect is in a new infancy in an evolving building industry. Further, that the development of cost methods for estimating new projects were outlined as a potential new service for the architect (Burr and Jones, 2010). The interest for discussion of this area can thereby be underlined. Results from this case study indicate that the architects see possibilities in claiming properties beyond developing the design. The already integrated division for project management within the case company can be considered as one such indicator, the interest in additional project aspects such as costs another. In addition, as expressed by the architects in interviews - it is about reclaiming a previous stronger professional role and a role more similar to that among colleagues abroad. As summarized by many of the respondents, this increased interest in the economical aspect is considered as one aspect in order to reinforce the role. The role of the architect can be seen discussed recently in the Swedish construction industry.

The *Organization for Swedish Building Industry* recently published an article where it is summarized and argued from the architect's perspective that "the construction industry and overall building process would benefit if the architect had an increased influence and responsibility in the building process" (Byggindustrin, 2016). Reinforced knowledge in project management and project economy was an aspect argued to contribute to this. It can further be discussed that the architect can be able to contribute with other qualities to the industry, comparable to e.g. the larger contractors on the Swedish market. This in terms of a variety in our building environment rather than favouring standardised solutions and large volumes. In relation to this, it can be reasoned that the contractor sees other values in working towards an increased influence and control of the design phase, in order to ease steering later in the production phase. Thus, a wider argument can be raised that there are several parties interested in a leading role in the project design phase.

However, findings from this case study also indicate an increased level of cooperation and communication with the contractor. This, since the partnering collaboration

method was indicated by most interviewees to be applied for an increased number of projects. Further, this was emphasized as a successful collaboration constellation by all parties: the client's, client and contractor's as well as architect's perspective. An analysis of this might be that through new technology and new development in for example cost estimation, roles within the process can change, and new ways of collaboration can arise.

7 Conclusion

The main objective of this study was to identify the values and challenges for architects in performing cost estimations in an early design phase, and to investigate whether BIM could impact or support this. Further, to look at what factors that are important regarding implementation of new practices such as cost estimation. The research method included a theoretical review on the subject as well as a case study at a Swedish architectural firm, where semi-structured interviewed were conducted. Additionally, interviews were held with clients of the case firm to get a broader perspective of the subject.

The cost estimations that are found as most valuable in this context are concluded to be of smaller, in this study referred to as, internal architectural part-estimates. Additionally, simultaneously increasing the overall cost awareness is something found in this study to potentially bring large value to the architectural practice and their projects. The values of early cost estimations among architects is found in this study to be largest internally for the architects' own processes, however also wider external gains are found in this study such as increasing competitiveness and gain larger trust from clients.

The main overall potential value in being able to do such estimates is to become more confident and better be able to argue for the architectural objectives and values of a project. Further, through this the amount of cases in which architectural values need to be compromised on later in the project process due to economic reasons can be decreased. It is further found in this study that there are some challenges related to early cost estimations, some specifically related to architects being able to do such, some concerning the internal processes, and others more general.

BIM is concluded in this study to be able to support in this context. However, some cost aspects are brought up in this case study's findings, which potentially cannot be calculated or estimated with the help of BIM. It is nevertheless suggested by the authors of this study that using BIM as base for the smaller partly cost estimates stated, such as comparing choices in design: e.g. materials, structures, glass areas etc., can be valuable. However, also in this context some challenges are identified that are important to take into consideration if introducing new cost estimation practices within the organization. These are mainly concerning to maintain a free and creative design process, ensure the level of information needed in the model in order to perform a decent cost estimation as well as the expertise of the estimator. It can be concluded that the challenges identified in this study related to performing early cost estimations make up an important part of what needs to be considered in implementation. In addition, a good implementation strategy is needed.

Lastly, findings from this study suggest that as of today it is more of a project manager role in the early project processes and a client representative role that can be reinforced for the architect rather than providing estimates as a consultant service. The latter is found in this study to be considered by all parties to be best performed by the contractor. However, with the development of new efficient methods and tools for cost estimations, the roles and responsibilities within the project process may change.

7.1 Critical view on conducted research

The objectivity of this study can be somewhat questioned. As Bryman (2012) points out, complete objectivity is difficult in social research. Further, it can be argued that when analysing qualitative data, interferences of what has been expressed by the interviewees need to be done in order to generalize findings. However, methods for validation have been applied in order to address this matter.

Limitations of this case study concern that of *one* case company constituting the interviews conducted with architects. Interesting might have been to include other architectural firms' view on the topic. A somewhat similar pattern in response and data material from interviews was seen. Some of these findings can be argued to be connected to employees working in the same context. Two clients have been included in this research, one of which functions as both client and contractor. Nevertheless, it provides an indication of different viewpoints in the industry and can be put in relation to that of focus for this study; the architects' views. Findings from this case study provide an example of what might be of interest for the architect to develop in their profession, and in the years to come.

7.2 Suggestions for further research

Though findings of this study suggest that architects do not have enough winnings in taking over the role as calculator in projects, the authors suggest that it could be of interest to study if among other clients, possibly smaller, it could be of larger interest in architects doing so and providing that expertise. Further, the difference in the architectural profession and their cost knowledge and processes between Sweden and other countries have only been briefly touched in this study. An interesting further research would be one comparing different countries - in order to get a clearer view of the winnings and possibilities in architects entering new markets.

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Appendix I: Case Company interview guide

(Architects/BIM Manager/Project Managers)

1. What is your current role in the company?
2. What does your previous experience look like? (Roll/Position? Time in the company?)
3. Are costs something that are discussed in your projects?
    a. In such case, what costs? (e.g. Materials, quantities, technical solutions, etc.)
4. If they are discussed, when do they first arise and in which stage do they have the largest focus?
5. Do you ever get feedback on costs/budget before finished proposal documents?
6. How often does it happen that you must compromise on design and architectural values after finished proposal documents in projects due to costs?
7. Do you see that you as a company has anything to gain on an increased cost awareness in early design stages and in such case what?
8. What type of contract forms/procurement methods do you mostly work with?
9. *To project managers*: In the projects in which you are involved, who takes on the roll as estimator?
    a. Does this look differently depending on contract form/procurement method?
10. Do you see that the architect's roll might change with an increased cost awareness, and in such case how? (Both in early stages and throughout the whole project process)
11. How do you think an increased cost awareness might affect your design process?
12. How do you think an increased cost awareness might affect your relationship with clients?
13. When in the design process (how early) would it be of interest to be able to estimate project costs?
14. What economic variables do you see as important to be able to estimate for your design process and should thus be included in such an estimate?
15. Do you see any challenges with early cost estimations?
16. What role does BIM play in your design process?
    a. Does this look the same in all projects?
17. Do you see any possibilities with BIM in concerns of being used as basis for cost estimations?
18. Do you see any challenges with BIM in concerns of being used as basis for cost estimations?

Additional questions to BIM Manager

1. How much information can you today assign to or extract from your BIM models?
2. What information do usually the BIM models which you send forward to clients for estimates include?
3. Does the amount of information sent vary between clients?
4. What is your opinion on the existing tools for cost estimations that exist on the market today?

Appendix II: Client interview guide

1. What is your current role at the company?
2. What does your previous experience include? (Role, position and duration at the company?)
3. How are costs discussed at early project stage in your projects?
4. When and how (within early project stage) are costs brought up for discussion?
    a. When is it most important?
5. Who takes on the role of the calculator on your projects?
    a. In-house/consultant?
6. How are cost estimations performed in your projects? (Based on 2D-drawings/BIM/Databases)
    a. Which cost factors are included in such estimations?
    b. How often are they performed?
    c. Is the same process used for each project?
7. What challenges are there in early cost estimations?
    a. Are the cost estimations that are done early reasonable?
8. When and how (frequency) during the design process are costs discussed with the architects?
9. What information from the architects provide the basis for your cost estimations?
    a. Is the transfer of this information simple or complex and time-consuming?
10. What role does BIM play on your projects in the context of cost estimations?
    a. Is information from BIM models used for calculation?
11. Would it be of interest to see an increased cost awareness among architects?
    a. If so, what cost factors are most important to include at early project stage?
    b. How would this affect your project process in early project stage?
12. When at early design stage would it be of interest to receive a cost estimation from the architect?
13. Do you see that the role of the calculator could possibly change in the future?
14. How do you choose architects for your projects?
    a. What aspects are looked at?
    b. If different architectural firms are chosen among, how is the final decision made (what factors are looked upon)?