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Small big BIM

Diffusion of BIM technology in small architecture offices

Master’s thesis in Design and Construction Project Management

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Abstract

Recently many big construction companies implemented BIM in first hand, proving positive results in complex and major constructions. However, literature has shown that many SMEs in this industry struggle or resist changing toward BIM. This study aimed at understanding how BIM diffusion is developing in small architecture offices in the Swedish market by inquiring to what extent is BIM implementation taking place and identifying what are the recurrent challenges and drivers. Moreover, a literature review was provided to support this study and an institutional theoretical lens was adopted to understand and identify the isomorphic processes taking place for BIM adoption. For this purpose, using a qualitative methodology, interviews were performed in five small architecture offices up to 20 employees and two software companies.

Findings show that the client has been stated as being either a driver or a challenge in BIM implementation, depending on the age of the company, growth rate, and type of projects. According to the selected data there is a need for BIM perception and requirements alignment in the market since extensive BIM manuals differ between companies, municipalities and other public clients. Moreover, normative isomorphic pressures have been found to be significant when it comes to education and universities. This creates a demand for the employers to shape their organizations and creates an internal motivation and competence for BIM that spreads through project team members.

Key words: BIM Diffusion; BIM implementation; architecture; institutional theory; design management; architect;

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Preface

We would like to thank all of our teachers in Chalmers for the provided learning experience and support throughout the master program. Among those we would like to acknowledge and appreciate the support from our supervisor, Petra Bosch, for being always available and providing detailed feedback and open guidance for this study. Moreover, we would like to thank our head of program, Martine Buser, for all the guidance and support not only in the master's thesis but also through the whole master program. Furthermore, we want to thank all our participants, without whose cooperation we would not have been able to conduct this analysis.

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This learning experience has been the perfect ending for our journey through Chalmers.

We hope you enjoy your reading,

João Monteiro & Jonas Diezel

List of abbreviations

AEC	Architecture, Engineering and Construction
AIA	American Institute of Architects
BCF	BIM collaboration format
BIM	Building Information Modelling
BIM	Building Information Management
IPD	Integrated Project Delivery
ICT	Information and Communication Technology
IFC	Industry Foundation Classes
PD	Pre-design stage
SD	Schematic Design stage
SME	Small and Medium Enterprises
TAM	Technology Acceptance Model
DD	Design Development / Detailed Design stage
CD	Construction Detailing / Documentation stage
2D	Two-dimensional design
3D	Three-dimensional design
CAD	Computer Aided Design

1 Introduction

In this chapter a brief description of the background on the construction industry and BIM is provided. Furthermore, a general description of BIM is presented to better understand the choice of topic description and the aim of this study. Finally, several research questions are presented and explained within the scope of the study.

1.1 BIM in the AEC Industry

1.1.1 Background

Since the first reference to the concept of Building Information Model (BIM), many have drawn attention to its benefits and potential yet to be discovered. *"With BIM technology, an accurate virtual model of a building is digitally constructed. This model, known as a building information model, can be used for planning, design, construction, and operation of the facility."* (Azhar, 2011, p. 241). It can be treated as advanced evolution of Computer-Aided Design (CAD) and implementing BIM technology will develop the construction sector, increasing the efficiency through improved collaboration between the different disciplines, less collisions and less work on adjustments and corrections (Migilinskasa , Popovb et. al., 2013). BIM has in fact been presented as a new paradigm in the Architecture, Engineering and Construction (AEC) Industry. With many definitions, that range from a tool or combination of digital tools up to a methodology and philosophy, BIM has already produced significant changes in the industry that extend through design, production, and facility management, connecting them in an unprecedented way.

In addition to that, big companies implemented BIM at first hand, proving positive results in complex and major constructions such as infrastructures, public buildings, and big residential blocks. Whether by public regulations or by private initiative, the BIM format has begun to be the standard in project delivery in several countries, like Sweden, Singapore, and United Kingdom. As for the medium/small companies, the implementation of BIM has progressed in different ways. Literature has shown that many of these companies struggle or resist the adoption of this information and communication technology (ICT) (Bosch-Sijtsema et al., 2017).

As an overall description Azhar (2011) describes BIM as a tool to decrease project cost, increase productivity, quality, and to reduce the project delivery time. BIM simulates the construction project in a virtual environment, it provides an accurate virtual model which is digitally constructed through a software. After finishing the model, it contains precise geometry and relevant data to support the procurement, design, construction activities and fabrication which are required to realize the project (Eastman et al., 2008). Furthermore, this model can be used for operations and maintenance purposes and demonstrate the entire project life cycle.

There is considerable empirical research where positive effects where found by the use of BIM technology by large enterprises on mega projects (Taylor and Bernstein, 2009; Davies and Harty, 2013) and some research advocates that BIM is not for small and medium sized firms (Arayici et al., 2011; Leeuwis et al., 2013).In addition to that, when it comes to architecture offices, there is little research about BIM implementation in the Swedish market, The American Institute of Architects (AIA) came up with a definition of how a small company in the architecture field could be defined. They suggest that over 95% of the firms that classify themselves as a small business are fewer than 20 employees. Moreover, Klein (2010) supports this statement by saying that a small architecture firm has less than 20 employees (Haliburton, 2016). "*Some of the small- and medium sized firms are beginning to use BIM; however, there is little understanding of how BIM is perceived by the practitioners in this sector*" (Jaradat and Sexton, 2016).

1.2 Problem statement

1.2.1 Aim of this study

As mentioned earlier in the background, literature reveals many of the benefits of BIM technology in the AEC Industry. BIM technology is perceived as catalyst for many changes happening in the industry. In addition to that, some literature also draws attention to an over optimistic BIM enthusiast perspective. Fox (2014) identifies fallacies in the BIM literature that are generated by over optimist studies. Instead he proposes a model of critical realistic description where BIM can be implemented without neglecting important hindrances or challenges. Moreover, results in BIM implementation have been characterized as intangible and difficult to measure, as Vass and Gustafson (2015) and Becerik-Gerber and Rice (2010) conclude.

A literature review provided the basis to understand how BIM diffusion is developing in small architecture offices and identifies the challenges and drivers when changing from a previous methodology. Furthermore, an institutional theoretical lens was adopted to understand and identify the isomorphic processes taking place for BIM adoption in this type of company. Although there seems to be a lot of literature on the benefits of BIM, a sense of over enthusiasm is also pointed out. Therefore, this study aims at understanding how and if the BIM implementation is being carried out in the selected small architecture offices up to 20 employees.

Furthermore, it is the purpose of this study to provide clues to further research that could help small design offices with limited resources to make the right investment and management decisions when it comes to innovation and new technologies that can be interlinked with BIM. By identifying the challenges and drivers of BIM implementation in small architecture offices, this study aims to provide knowledge that can be of assistance to architects, but also other AEC professionals involved in the design phase to deal with these challenges in an efficient way.

1.2.2 Research questions

The main research question in this study – RQA: *How is BIM diffusion developing in small architecture offices?*
The main research question arises from the research gap earlier described and a need for BIM management knowledge I small and medium sized enterprises (SME) in architecture. There are few or no indicators on how architects are working with BIM in SME in Sweden or if they are using this technology at all. After answering this question, we wish to provide a better picture of BIM diffusion in this discipline and the most frequent challenges and drivers associated. The term BIM diffusion is used as the level of which the technology is spreading in several companies while BIM implementation only relates to the process happening in some companies.

RQ1. W*hat is the perception of the concept of BIM in small architecture offices?* Being a relatively recent technological innovation with several definitions, it's necessary to understand what designers or business owners are referring to when they talk about BIM. The objective of this question is also to understand to what extent are they implement this technology.

RQ2. – *What are the challenges and drivers of BIM implementation in small architecture offices?*
In this field both negative and positive influences, on the on-going BIM implementation process, are discussed. The primary objective is to understand which challenges and drivers are most referred. Moreover, the learning processes of BIM implementation are discussed and identified.

RQ3. – *What are the external influences in small architecture offices when adopting BIM in a project?*
The inter-organizational connections in the construction industry produce norms and knowledge that helps to shape and create new institutions. With this question the purpose is to underline which actors and institutions can influence and shape BIM diffusion in small architecture offices. Moreover, the project requirements and BIM competence in different clients can influence BIM applications or even the decision to use BIM at all in a given project.

1.2.3 Scope

The scope of this study, as described before, revolves around BIM diffusion in small architecture offices, up to twenty employees, located in Sweden.
To clarify the terms "implementation" and "diffusion" Oxford English dictionary described the term "implementation": *"as the process of putting a decision or plan into effect; execution*" and "diffusion" as: *"the spreading of something more widely"*. The option to use the term "diffusion" in the title of this research is to include the offices

that still aren't implementing BIM while still being subject to institutional isomorphic pressures. While the term "implementation" is used in the sections where the objective is to study the process of implementation in the companies where it is already taking place.

This study will focus on the design management field and on the architecture discipline's connection with a specific set of ICT tools. Therefore, it won't analyse other aspects or roles in the full life cycle of the project if they are not directly connected in a significant way to the design stages. In that sense, multidisciplinary teams and meetings with other disciplines in the design stage can be addressed to better understand the implications of BIM within office daily activities. For that matter this study will analyse the organizational culture when it comes to dealing with technology and how that can change the individual and group perspective on BIM software usage.

Furthermore, the research is containing the inquiry of management decisions that are taking place in the companies when it comes to BIM implementation and team management in BIM projects. To get an idea of how a software provider is working we are looking at their implementation strategy, cost estimations and seller strategy.

1.2.4 Structure

This paper begins with the present chapter, with the given background to contextualize current situation regarding BIM in the AEC industry in Sweden. Moreover, the problem statement, research questions and scope are provided.
The following chapter, the theoretical framework is structured with the selected theoretical lens on institutional theory, followed by literature on BIM and BIM implementations and concluded with a description of the BIM definition adopted for this study. In the third chapter, methodology, the research design options are presented and justified, along with ethical considerations. After that, the Empirical Data chapter presents the results of the data collection and is summarized in the end.
In the fifth chapter, Discussion, the results are reflected upon using both literature and the theoretical lens. Finally, concluding remarks are presented and some possible further research suggestions are formulated.

2 Theoretical framework

In this chapter a theoretical lens is presented to provide a model to be used in empirical data analysis. Moreover, key literature on BIM implementation studies is summarized to give an overview of important concepts or models that have been previously used when researching the selected topic. Finally, a third subchapter concludes the theoretical framework by combining literature to produce a BIM definition to be used in this research.

2.1 Theoretical lens

2.1.1 Institutional theory

DiMaggio and Powel (1983), contributed to the Institutional Theory and isomorphism in the classical paper: *“The iron cage revisited: institutional isomorphism and collective rationality in organizational fields”*. Instead of aiming to explain diversity in organizations, as other authors did, this paper aimed at explaining increasing homogeneity in organizational fields. This paper relevance has increased over the years, especially in the sociology, business and management, being the management field the one with higher citations count (Greenwood and Meyer, 2008).

The iron cage is a metaphor borrowed from the German sociologist and philosopher Max Weber. According to Weber, the Iron Cage would represent bureaucracy to structure organizations and a way of organizing society but also to exert power over men and women in a modern post-industrial word. The capitalist market and competition would be the real driver in demand for bureaucratization in organizations. *“(...) under capitalism, the rational order had become an iron cage in which humanity was, save for the possibility of prophetical revival, imprisoned “perhaps until the last ton of coal has been burnt”* (Weber, cited in DiMaggio and Powel, 1983, p.147)

In this sense, the iron cage is revisited to reinterpret it according to evidence witnessed at that time, and as some argue, persisting in current time. The general argument was that the causes for rationalization and bureaucracy in the organizational fields were not so much related with technology and resource dependent theories as with in the "institutional forces", represented by the state, the professions, the schools, the courts and other forms of institutional influence. The described paradox is that of actors that make their organizations increasingly similar while they try to change it. However, there have been many developments since the early eighties regarding the different trends arising from the institutional theory. Institutional theory can be seen today as reaching its maturity level and giving birth to many different empirical studies, I.e. the deinstitutionalization processes or the decay of institutions while they give birth to new configuration networks (Scott, 2008)

According to DiMaggio and Powel (1983), organizational fields cannot be defined a priori, instead, they must be determined based on empirical investigation. Moreover, a field only exists to the extent that they are institutionally defined. There are four elements present in the process of structuring or institutional definition:

a. an increase of interaction among organizations in the field;
b. well defined inter-organizational structures and patterns of coalition;
c. an increase in information with which organizations in a field much contend;
d. a mutual awareness in a set of organizations that they are together in an enterprise.

Therefore, it's this process of institutionalization that gives origin to powerful forces that push organizations to isomorphism. The Merriam-Webster dictionary (2018) defines isomorphism as a similarity in organisms of different ancestry resulting from convergence. The reasons for isomorphism come from multiple sources being the state, the professions, or others as further explained. In this perspective, rational actors in charge of making decisions also construct around themselves this perceived environment that constrains them from making decisions that will produce change in their organizations for the coming years. *"As an innovation spreads, a threshold is reached beyond which adoption provides legitimacy rather than improves performance"* (Meyer and Rowan, cited in DiMaggio and Powel, 1983, p. 148).

There are two types of isomorphic institutional change: competitive and institutional. Competitive isomorphism is more connected with the iron cage vision of Weber. In free market competition different actors make strategic options, find niches, battle for resources and customers. However, this vision alone, the competitive isomorphism, does not provide a clear and global perspective of how modern organizations develop and interact. For that, the previous one must be complemented with intuitional isomorphism that is the other organizations themselves make an eco-system in which every single organization must navigate act and be acted upon. In that sense, organizations don't battle just for customers, resources or new technologies, they also battle for institutional recognition and political power.

DiMaggio and Powel (1983) have identified an analytical model of three mechanisms (that can be combined) through which institutional isomorphism occurs:

a. Coercive
b. Mimetic
c. Normative

Coercive isomorphism is the mechanism that occurs when both formal and informal pressure is exerted by political and government organizations but also other types of organizations or groups in society. This can be easily observed in regulations and laws that organizations must comply with. I.e. the simple fact that the companies must have a yearly budget or present financial statements is already a mechanism that ties all the companies closer together. Many other regulations or forms of pressure are exerted by the political power. In turn, this political power can have an isomorphic effect perhaps because the decisions and regulations cover a wide range or organizations rather than being more specific and adaptive, which could in turn create more regulations and bureaucratic "noise". However, this mechanism has other less explicit and direct forms of existence. Neighbourhood communities or apartment buildings condominiums, and the need for non-hierarchical organizations for still have a top representative that will account for that or organization in meeting with the "normal" hierarchized organizations. In DiMaggio and Powel's paper the free schools of the educational system at that time are given as an example of the last hierarchy described problem. In schools with no appointed principal due to their flat hierarchy, these would still have to appoint a principal to deal with the regional superintendent and participate in meetings on the school's behalf.

Mimetic process is related with imitating other organizations because of uncertainty or other reasons such as lack in innovation and research or peer pressure. The model organization is the term applied to the organization that conscious or not, willing or not, ends up by serving as a model for other companies, the borrowing companies. However, simple imitating processes can be also innovative since organizations can, unwillingly, create innovation by copying or adapting a model into their own context, or simply by trying to copy uniqueness. Furthermore, mimetic process can also be related with the fact that most organizations have a relatively reduce variations selection to choose from or simply because they make the safe option to build an organization based on a previous existing modelled organization which is seen as a legitimate and successful one.

Normative isomorphism processes are those that arise from professionalization. Professionalization is interpreted here as *"the collective struggle of members of an occupation to define the conditions and methods of their work, to control the production of "producers""* (Larson and Collins, cited in DiMaggio and Powel, 1983, p. 152). Professions are not generally subject of coercive or mimetic pressure, but they can also exert influence over multiple organizations since most of organizations are multidisciplinary. DiMaggio and Powel (1983) identify two sources of professional influence. One is in education and universities since specialists, researchers and professors and students form a studying environment context where a cognitive base is established. Secondly, the profession communities and associations grow to be stronger and more connected communities than before, and they use their influence and shape organizations according to their own interests.

2.1.2 Institutional theory in the construction sector

The Industry sector's main organizational form is the project-based organization, since every project has its own objectives, and actors or stakeholders with different needs and demands. In this sense, one might expect that the uniqueness of each project would provide more flexibility. However, as seen in the Swedish construction industry sector, there is a strong institutional influence that shapes these projects into similar organizational forms. Kadefors (1995) argues that maybe projects are not so unique and context dependent as one would expect in a project-based environment. "The buildings, the work processes and the occupational roles are all heavily institutionalized. While they promote efficiency, these institutions constrain flexibility. As became obvious in the case study project, attempts to deviate from the established practices are met with great resistance." (Kadefors, 1995, p. 404).

While understanding BIM as a collaborative tool that can be present in all stages of the project life-cycle, it is important to analyse how the institutional landscape in the construction sector is constructed and in what way it relates to BIM technologies. Part of the research performed in BIM implementation focus on innovation in the contraction sector from the ICT user perspective, with models such as the Technology Acceptance Model (TAM). However, several other authors believe that being BIM a complex and influential innovation it should be studied within the highly complex institutional network that forms the AEC sector.

In their study, Cao et. Al (2014), collected and analysed data on how coercive, mimetic and normative pressures influence the process of BIM adoption in construction projects in China. For that, they combined the isomorphic pressures with the influence of the client/owner, since the last one can be crucial in innovation processes in the sector. Viewing BIM as a highly complex innovation that requires working processes redesign to reach a full potential, organizational change will become more obvious when BIM goes from the modelling stage to the integration phase, thus requiring more support and input from the client/owner (Succar, cited in Cao et. Al, 2014). The results in this study, considering the Chinese construction sector, indicate that isomorphic pressures have been found to influence BIM adoption in a significant way. Coercive pressures have high impact on the client/owner when it comes to BIM adaptation, especially when comparing with normative pressures, which despite active, have not been successfully targeted client/owners. Mimetic pressures have also been found to exist, although in a lower level. The study revealed that the client/owner acts a mediator in the mimetic pressures but also that several participants like architects and engineers, because of their professional knowledge and institutional environment, are exposed to mimetic pressures without the influence of the client/owner.

Empirical data of this study has shown that BIM is regarded as a highly social activity, motivated not only by proactive efficiency, but also influenced by institutional isomorphic pressures (Cao et. Al, 2014). Nevertheless, care should be taken to avoid a blind BIM adoption without considering the project needs. Moreover, being the client/owner an influential actor in the project, results suggest that normative pressures should target this actor in the construction sector. Finally, its suggested that construction professionals can better exert their influence if they present the benefits of

BIM implementation in similar projects to the one pursued by the client instead of presenting the benefits of BIM in specific study case projects.

From these studies, it can be understood why there is a need for a strong institutional network in the construction industry sector. This is due to several uncertainty factors in a project, a temporary entity with specific objectives and demands. Moreover, the number and complexity of actors involved in a project with interdependent tasks and being object of a strong influence from the public sector, increase the demand for coordination. In this sense, the interdependence of organizations involved in the project confirms the notion that interdependence increases the cohesive force of institutions (Powell, cited in Kadefors, 1995). The need for a high degree of communication in interdependent tasks demand a high institutional environment where all the actors should communicate and act in an expected way, to reduce uncertainty and increase efficiency.

BIM is a technology that changes working processes and the way that different actors collaborate and communicate in the construction industry. In this sense BIM has the potential to be an agent of change or disruption of well-established roles in this complex existing institutional environment or by creating new roles and institutions, like for example the one of BIM-coordinator. In this sense, small architecture offices and the architect as an entrepreneur must find his place in a changing institutional environment.

2.2 BIM literature and architecture practise

2.2.1 The role of the architect in Sweden

Due to the factors earlier discussed, the construction industry is intrinsically constituted by a complex and strong institutional environment. In Sweden, the role of the architect in this institutional network is somewhat different from other countries, even Scandinavian ones. Bröchner et al. (2002) analyse the Swedish construction culture and its actors connecting it also with the national culture. Despite the lack of evidence for a direct link between cultural values and behaviour in construction projects (Winch et al., cited in Bröchner, 2002), by studying the culture it´s possible to understand how it influences the institutional and organizational behaviour in the construction sector.

According to Bröchner et al. (2002) the Swedish construction industry has low acceptance towards elites, thus weakening the role of the architect throughout the different stages of the project. This low acceptance comes from the construction culture and national culture where egalitarianism, low power distance leadership, a low degree of uncertainty acceptance and lowest extreme of the scale for masculinity can be found, as indicated by cultural studies in 1980 and 1991 (Hofsted, cited in Bröchner, 2002). In addition to that, the avoidance of conflict and strong levels of trust, characterize this environment where the architect does not stand out.

Furthermore, the explanation for the weak influence of the architect and other professions in Sweden can be explained by the strong influence of the state. The gap between the architecture and engineering curriculum has been filled with broader engineering studies instead of assuming “building” as a separate field. However, as Kanters et al. (2012) point out, there are Swedish architects that feel that the architecture curriculum has little of technical knowledge while others think that it should mainly address the aesthetics of buildings since most of the technical knowledge is part of the second phase of learning when the professional life starts. *“There are a lot of people you can just call and ask [regarding solar energy products]; ‘How big is the tank? How much insulation do we need?’ There is no one you can call and ask ‘is it nice or ugly with this roof angle?".* You have to learn that in school (architect #2, in Kanters, 2012, p. 146).

The architects and engineers' association have little influence over the curriculum in education for the construction sector. Architects and engineers in Sweden act has mere consultants, instead of leading management positions. Moreover, like in other countries, there is a fundamental tension between technology and aesthetics that has been noticed between engineers and architects throughout the 20th century (Larsson, cited in Bröchner, 2002). However, according to Kanters et al. (2012) many architects don’t see the need for more technical knowledge in the architecture curriculum also because they work in close collaboration with engineers.

In their report, Graninger and Knuthammar (2010) pose two possible ways for the development of the role of the Swedish architect and the construction industry in Sweden. They analyse the construction sector drawing attention to the power that is retained by the Swedish biggest contractors in a process that started in the early 2000's. This analysis is done also by comparing the biggest actors in the industry according to type and country in Scandinavia.

In one possible development the big contractors keep retaining power with a weakened role by other actors while in the alternative way a more balanced distribution of power between all construction actors, including the architect. Moreover, they claim that this balance of power was originally established since the 1950's when Sweden had a leading role in architecture quality. The challenges posed to the Swedish architect are related to the pursuit of architecture quality and what role can the architect proclaim in new institutional landscape with the turn of the century. The emergence of new roles and technologies like the BIM coordinator also create new interactions between actors that architects can explore and perhaps take a bigger role in the renovation in the Swedish construction culture. BIM is affecting the traditional way of working as an architect in a new way.

2.2.2 BIM Definitions and applications

It is important to understand that build information modelling (BIM) is not just a software, it is a software and a working process. So, it is not only about using the 3D model by its own it is also about making significant changes in the workflow and project delivery processes (Hardin, 2009). Moreover, Aranda-Mena et al. (2009) are stating that there are different kind of understandings what BIM is. BIM is also getting defined as build information management because the factor management is bigger than actual the modelling (McArthur, 2015).

The BIM model can characterize the geometry, spatial relationships, geographic information, quantities and properties of building elements, cost estimates, material inventories and project schedule. Moreover, it is possible to extract quantities and shared properties of materials. Different kind of work processes can be shown and easily exported through the model (Bazjanac, 2006). Documents like 2D drawings, procurement details, submittal processes and other specifications can be interrelated or exported through the model and shared among the disciplines. Through BIM, all disciplines (engineers, architects, owners, contractors, subcontractors, and suppliers) are able to work within a single, virtual model, allowing them to collaborate more efficiently and accurately than using the traditional ways. While the model is being created, the team members are constantly refining and adjusting their parts according to the specifications of the project and design changes to ensure that the model is as accurate as possible it could get until it finally can be built physically (Azhar, 2011).

As an example of how the BIM model is getting used we see in fig. 1 the typical applications of BIM at different project stages (Azhar, 2011).

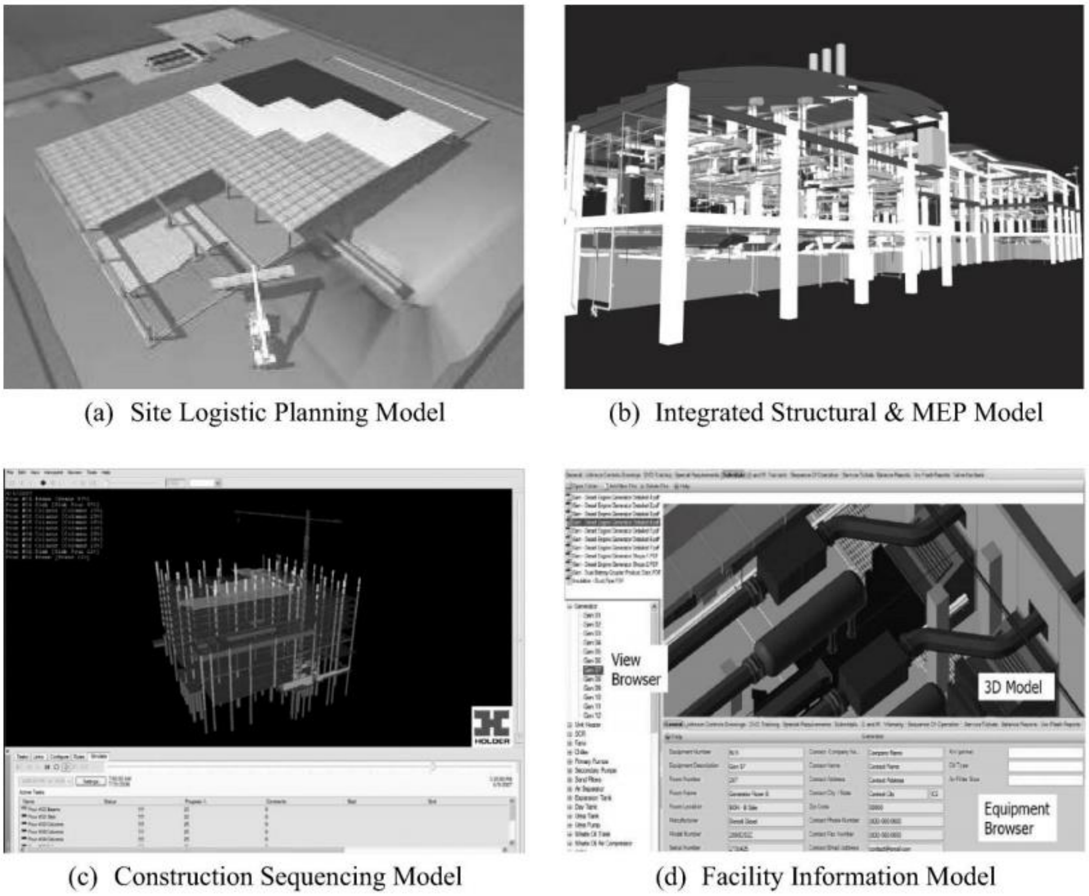

Figure 1 - Different components of a building information model: MEP = mechanical, electrical, and plumbing (Azhar, 2011, p. 242)

BIM encourages the integration of the roles of all stakeholders in a project, which lead to a greater efficiency and harmony among the parties (Hardin, 2009). Furthermore, integrated project delivery is getting supported by BIM, it provides a new way of approaching a project delivery by integrating people, systems and business structures and practices into a collaborative process to optimize efficiency and reduce waste through all phases of the project life cycle (Glick and Guggemos, 2009).

Furthermore, BIM can also be seen as a communication tool used by from the different disciplines. Demian & Walters (2014) settled a study where the effectiveness of BIM as a medium for communicating information within a construction team should be proved. The case studies for that study consisted of four very similar projects, each using a different information management system: e-mail, a construction project extranet tool, an Enterprise Resource Planning system and a new BIM-based system. After the study was done it turned out that BIM was the most efficient communication tool. The participants highlighted the core potential of BIM as a provider for a much better collaboration between the disciplines (Demian & Walters 2014). So, as the study approves BIM can also be seen as a tool for communication between networks of actors that contribute to produce a facility.

BIM gives the user the possibility to provide detailed sequences from the building. Furthermore, a visualisation of the interfaces between different elements of the building which are moreover referenced to time (Eastman et al, 2011). Moreover, *"BIM can produce visual representations and animated simulations of physical clashes between different elements of the building, and depending on model detail, between the building and temporary works"* (Campbell; Leite et al., cited in Eadie et al., 2013, p. 342). This provides the possibility to solve problems even before it occurs on the construction site which leads to a lot of rework and unnecessary costs (Azhar et al, 2008; Azhar, 2011). *"Significant time and cost-savings can be achieved through effective and efficient production works scheduling"* (Azhar, cited in Eadie et al., 2013, p. 342).

BIM as a design tool for the early stages of the project. Bryde et al. (2013) is adding that the 3D model gives the user the possibility to produce photorealistic visualisations, walkthrough and animations and therefore helping the client to understand the current situation better. Moreover, it gives a better platform for reducing the risks of misunderstandings. It gives the whole team the opportunity to work in a new way of collaboration.

2.2.3 BIM implementation definitions

The managerial issues of BIM implementation have been seen as a bigger challenge than the software by its own (Jung & Joo, 2011). Which get supported by Eastman et al. (2011) because a successful implementation is depending a lot on the management and project team skills, which are of a big importance.

The AIA has reported a disseminated Best Practices in 2007 from author Kirby (2007) who outlines a set of best practices for implementing BIM into smaller offices. The report sees the implementation as a cultural change and suggests that all firm members must contribute to the plan. Moreover, they state that it is important to have somebody who feels dedicated to the new technology, something like a manager or network administrator. Kirby (2007) also reinforces the importance of having hours of dedicated training. Moreover, it is not just working of the hours of workshops, the training must go beyond the workshops as well. In another study which was published in Automation in Construction in 2010 two authors were focusing on the people, processes and technology. *"BIM adoption would require a change in the existing work practice. An integrated model development needs greater collaboration and communication across disciplines."* (Ning Gu, 2010, p. 998). Furthermore, the outcome was that there was a lack of knowledge of how BIM could be integrated into current projects. (Ning Gu, 2010).

In 2010 there was an article published in Design intelligence by the authors Matta and Kam (2010) which came up with a scheme of six key points how to balance a strategic adoption plan of BIM:

1. *"Vision and value proposition*
2. *Insights and demonstrated evidences from pilot projects*
3. *Culture for constructive change that is shared across the organization*
4. *Training*
5. *Establish processes and partnering*
6. *Technology and alignment with proven and emerging software, scalable hardware, and infrastructure, as well as open standards"* (Matta and Kam, cited in Haliburton, 2016, p. 19-20)

This article was supporting the importance of the Human Capital or investing more time in the employees of an organisation, which includes training and education on the implementation and the benefits from BIM. Moreover, Mata and Kam (2010) states that *"the cultural transformation of an owner organization's human capital is key to successful BIM adoption"* (Matta and Kam, cited in Haliburton, 2016, p. 20).

According to Haliburton (2016) the firm culture has a big effect on the BIM adoption process and it seen as difficult topic when it comes to the adoption. Lu & Sexton (2009) sees BIM adoption as a knowledge-based approach which occurs with the development and integration of Human Capital (HC), Structure Capital (SC) and Relationship Capital (SC).

Human Capital (HC) — *"BIM adoption— quantifies the capabilities and motivations of the individual but focuses on how the firm cultivates and deals with individual employees."*

Structure Capital (SC) — *"BIM adoption—is focused on the systems, software, tools and processes the company uses to create, store, and share knowledge."*

Relationship Capital (RC) — *"BIM adoption—Includes both internal and external relationships. Internal relationships are those between individual workers and workers and their managers, or internal hierarchy. External relationships are those between workers and clients, consultants, contractors, and any other entity external to the company."* (Lu & Sexton, 2009, P. 16)

In addition to that, the BIM maturity levels matrix presented in the GCCG (2011), developed by Mark Bew and Mervyn Richards in 2008, presents different levels of BIM. Level 0 is defined as computer aided design (CAD) essentially this is a digital drawing board. Level 1 can be described as "lonely BIM" because in this stage the information is not getting shared among the disciplines. Level 2 is seen as a managed 3D model attached with data but created in separate discipline-based models. These models then get assembled to a single model but will not wont their identity or integrity. Furthermore time (4D) and cost (5D) are also taking into consideration in this level. Level 3 is defined as *"a single collaborative, online, project model with construction sequencing (4D), cost (5D) and project life-cycle information (6D). This is sometimes* *referred to as 'iBIM' (integrated BIM) and is intended to deliver better business outcomes."* (Thebimhub, 2017).

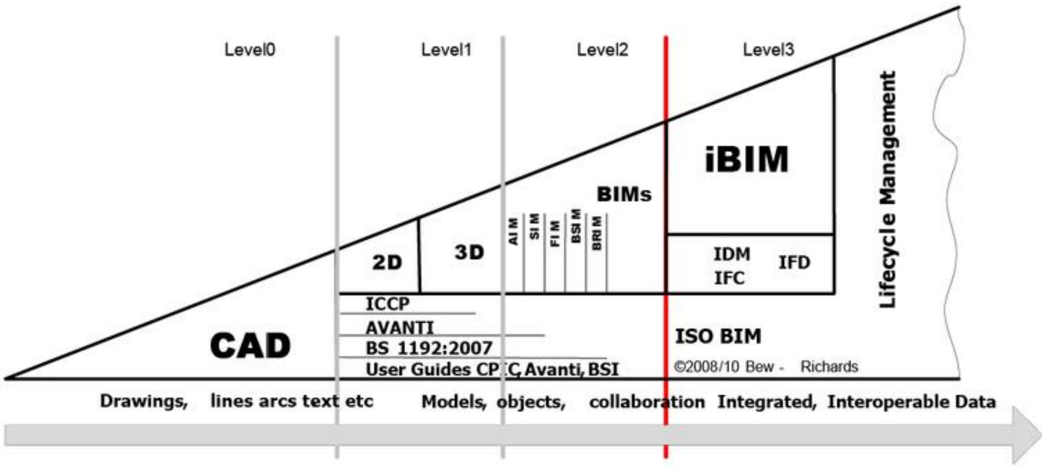

Figure 2 – BIM Maturity Levels, UK Government Construction Client Group (GCCG) report, 2011, p.16

2.2.4 BIM support in the design process and sustainability

According to the growing literature, BIM is going to change the way of working in architecture projects. Goldberg (2004, p. 56) states that: *"One of the greatest benefits of using a BIM application at the design stage is the ability for the designer to understand the relationships of the building and its systems instantaneously in regard to aesthetic, performance, and program issues."*. Moreover, Barlish & Sullivan (2012) are stating that *"The success of BIM depends on many factors such as the size of the project, team members' BIM proficiencies, the communication of the project team, as well as other organizational external factors."* (Barlish & Sullivan 2012, p. 158).

The interest going for BIM can be seen in conjunction with new project management frameworks, which craves for a more effective communication and a closer collaboration (Eastman et al., 2011). Traditionally, when changes have been made during the project this had to be documented and shared among the parties (Lee, 2008). So, back in the days the documentation had been done through physical paper and documents (BSI, 2010). Since the new technology has arrived on the market this approach has changed into a more digital way. BIM provides a virtual environment and *"allows a level of efficiency, communication and collaboration that exceeds those of traditional construction processes"* (Lee, cited in Bryde et al., p. 972). Furthermore, *"the coordination of complex project systems is perhaps the most popular application of BIM at this time. It is an ideal process to develop collaboration techniques and a commitment protocol among the team members…"* (Grilo and Jardim Goncalves, cited in Bryde et al., p. 972). Another side effect which comes with BIM is the approach to a leaner management of the projects. According to the more efficient collaboration and information sharing among the project which reduce the non-value-adding waste. (Bryde et al., 2013)

According to Eastman et al. (2011) the design process is typically divided up into six design processes:

- Feasibility studies;
- Pre-design (PD);
- Schematic Design (SD);
- Design Development (DD);
- Construction Detailing (CD);
- Construction Review.

The feasibility studies are *"nonspatial quantitative and textual project specification, dealing primarily with cash flows function or income generation"* (Eastman et al., 2011, p. 196). It connects areas, provides the required equipment and includes initial cost estimations. There may be some overlapping and iterations with predesign (PD), production or economic planning (Eastman et al., 2011). The purpose of the PD is to fix space and functionality of all requirements, setting up the different phases and provide possible expansion requirements. According to Bryde et al. (2013) the effect of using BIM in the design stage has shown as very positive. The preliminary project design with building plans is happening in the schematic design (SD) it shows how the predesign program could be realized. It provides volume models and early renderings of the concept. Moreover, it identifies the materials, finishes of the building and all building subsystems by the system type. Which is not only based on the client, it helps the whole design team to understand the current situation of the project.

The next step is the Design Development (DD) which is all about *"detailed floor plans including all major construction systems with general details"* (Eastman et al., 2011, p. 196). The Construction Detailing (CD) is about detailed plans for site preparation, grading demolition system specifications and materials. The last process is the Construction Review which is about *"coordination of details, reviews of layouts, material selection, and review"* (Eastman et al., 2011, p. 196). For this study the last three stages are not taken into consideration and therefore the design stages are considered bellow.

During the predesign phase it already requires a tool which can ideally contain architectural information, which then gets used for further developments during the whole lifecycle. BIM can provide these requirements by using a simple space model which contain attributes on definitions and usage, costs on unit and space to develop the project (Ham et al., 2008). By creating these simple models, the user is already able to develop the scale of the facility in an early stage of the project using BIM.

Furthermore, create/design the first draft on how the volume of the facility could look like.

During the design stage BIM can be used as an effectively analysis and evaluation tool. However, using it as an analysis and evaluations tool requires the creation of separate models for each discipline which then can get split up into specific models for evaluation. To support the analysis, it requires to spend a lot of time modifying the 3D model (Sanguinetti et al., 2011). Taking an architectural office as an example of BIM usage they are determining in the predesign stage of a project if BIM is getting used or not. Assuming BIM is getting approved the architect starts with a simple schematic model, by using simple volumes or even real elements in BIM. This model then gets presented to the owner which gives the opportunity for thoughts of how to proceed with the building. Scheduling (4D) and estimating (5D) gets already involved in the schematic design and this requires a correct modified model directly from the beginning of the project through BIM. It is important to insert everything correctly to uses the model for proper estimations. Which means to set up the right type, size, material etc. for each element used (Augi, 2012).

When it comes to the detailed design, collaboration is key. So weekly coordination meetings take place in the beginning of the projects which gets less during the project. As known BIM provides the possibility for creating a collaborative model which all the disciplines (the architects and engineers, project manager, estimator, scheduler and Construction Manager) have access to and all changes gets directly updated. Bryde et al. (2012) is supporting that statement by saying that the effect of using BIM is having a positive impact on the communication between the disciplines. Each discipline must send their model to a BIM coordinator who is assembling them. During meetings the clash-detection and Interference check software runs through the model to detect all clashes. This provides the possibility to solve the problems directly in an early stage of the project. If the model has been done correctly, everybody is now able to easily export and import sections, elevations, plans etc. from the model. Through the model it is possible to see who is responsible for which element this gives the disciplines the opportunity to contact the right person right ahead (Augi, 2012). When the design stage has been completed, the construction phase can start. Which is not taken into consideration for this study.

BIM is not only helping the construction industry for getting more efficient it also comes with a positive benefit regarding sustainability. Nowadays building accounts for almost 30% of greenhouse emissions and consume up to 40% of the total energy used in the United states (Azhar, 2009). According to this issue the demand for sustainable buildings with a decreased environmental impact are increasing. Regarding the sustainability the most effective decisions can be made in the beginning of the design and preconstruction stages. In this context BIM is able to provide a *"performing complex building performance analyses to ensure an optimized sustainable building design."* (Azhar, 2009, p. 276). Maltesea (2017) is stating that *"the use of BIM to* *provide data for energy performance evaluation and sustainability assessment is defined Green BIM."* (Maltesa, 2017, p. 1). It includes to identify options of how to optimise the building energy efficiency during the project life cycle. Moreover, by doing revisions during the design phase the contractor can ensure that the costumers green ambitions can be realized (Maltesa, 2017). *"The combination of sustainable design strategies and BIM technology has the potential to change the traditional design practices and to produce a high performance facility design."* (Azhar, 2009, p 278).

2.2.5 Challenges and drivers implementing BIM

Abbas Elmualim & Jonathan Gilder (2014) have come up with three major challenges which were ranked by their participants: *"training staff on new process/workflows; effectively implementing the new process/workflow; and understanding BIM enough to implement it. Other reasons were: training staff on new software/technology; establishing the new process/workflow; and realising the value from a financial perspective"* (Abbas Elmualim & Jonathan Gilder, 2014, p.197).

According to Barlish & Sullivan (2012) owners sometimes do not see the return on investment (ROI) and business value of BIM. There has been an eighth annual survey of owners describing the “BIM hurdles,”. *"The difficulties with the evaluation of the business benefits of information systems can be best categorized into six areas: (1) some of the business benefits may be intangible; (2) organizational changes may occur as a result of the introduction of a new system; (3) business benefits are evolutionary over the life-cycle of the system; (4) diverse stakeholders involved will subjectively evaluate the system and may have conflicting opinions; (5) users may feel intimidation or fear of the new system and how it will affect their jobs negatively; and (6) practical difficulties such as improper utilization, interconnected systems, and inability to divide related systems and benefits."* (Barlish & Sullivan, 2012, p. 154). Furthermore, Bryde et al. (2013) is adding that there are challenges with the software and hardware. The employees may not have the right knowledge handling the new technology. These issues could have kept low by giving all the employees involved better training and that stakeholder should be more open to allow the key actors getting more used to the new way of working. Furthermore, the extra time which must be used creating the model or sometimes even reconstructing the drawings *"from traditional CAD standards to a BIM platform"* (Bryde et al., 2013, p. 977) are very time and cost consuming (Bryde et al., 2013).

Eadie et al. (2013) made a study about the drivers of implementing BIM the research sample was limited to the top 100 UK construction contractors. The survey took place online were they were able to rank the importance of the listed drivers going for BIM. *"The study concluded that those who had adopted BIM ranked the drivers for BIM differently than those yet to implement a BIM solution."* (Eadie et al., 2013, p. 346). The overall three biggest drivers for implementing BIM where "1st Clash detection", " 2nd Government Pressure" and "3rd Competitive Pressure" (Eadie et al., 2013). According to Liu et al. (2010) the external forces from client and competitors are a big reason why BIM is getting more important. This is statement is getting underlined by Coates et al. (2010) who states that this is one of the key reasons for architecture offices going for BIM. Furthermore, the following driver which are taken into consideration for our study were: "6th Client pressure". These could be grouped under *"pressure from external sources while operational drivers were more important for users of BIM."* (Eadie et al., 2013, p. 338). The rankings from their survey indicates that the participants got influenced by the benefits of BIM implementation and not directly about the drivers.

2.3 BIM definition for this study

For this study BIM is not only defined as a software tool and working process, rather it provides a new integrated way of thinking. It is a new method for collaboration which are based on a better communication, commitments, transparency and all disciplines are participating in the design and construction process. Primarily, it is seen as a design tool for doing simple and complex 3D models which contains all data needed to provide different types of information like floorplans, facades, schedules and sections. Furthermore, provides the opportunity for all involved disciplinarians to work in real time on the same model. It is a tool which gives the possibility to run clash detections in an early stage of the project to keep the costs as small as possible.

Aspects we would like to look into further would be digging deeper into BIM cost estimations. How cost estimations are made through BIM and how accurate it could become. Moreover, how BIM could be used as project management tool.

3 Methodology

3.1 Approach to research

3.1.1 Research method

Through a qualitative research methodology, data was collected in eight semi structured interviews in five small architecture offices up to 20 employees and two software companies. The architecture offices and one software company are located in Sweden while the other software company is located in Germany.

The decision of selecting a range of different companies instead of one case study relates to the exploratory nature of the research question and to a broader sample that can provide systematic data for analysis. Therefore, this study will not entail applied research as it doesn't provide analysis or recommendations for one specific company. Instead, a general analysis will be carried out to understand the similarities, differences, and reflections that can emerge. This approach has the downside of not going too deep in one company. However, given the selected topic and the fact that there is literature gap concerning this topic, this research strategy was selected to provide a broader sample and multiple perspective on the same topic.

Furthermore, the software seller perspective provides a complementary view and data into the research questions. This provides a better understanding of how the product is sold according to the size of companies and the business strategies to overcome different challenges in different companies. As referred earlier, this methodology wasn't selected with the intention of finding and testing solutions. Instead, the aim is to find better and new research questions that can be explored further in other researches.

3.1.2 Research strategy

According to Creswell (2009), qualitative research is a means for exploring and understanding the meaning individual or groups ascribe for a social or human problem. This type of research has some intrinsic characteristics and the ones who use this form of inquiry support a way of looking at research that honours an inductive style, a focus on individual meaning and the complexity of a given phenomenon that can be better describe in quality instead of numbers.

Given the lack of literature for this specific topic in Sweden approach and the exploratory nature of this study, an inductive research strategy was adopted. Given the number of selected offices and the time used to conduct the research it was not possible to conduct qualitative inquiry procedures such as observation or focus groups, since this require more time and preparation. Therefore, the research strategy was proposed to produce an interview guide to be tested in the first interview and used systematically throughout the research. The data collection and data analysis further described in detail provided themes and answers to the research questions. The theoretical framework was then adjusted according found evidences and to produce an analysis diagram addressed in the discussion chapter.

3.2 Research design

3.2.1 Data collection and interview structure

Brinkman (2009) argues that the interview is an inquiry method better suited for matters that concern the human experience when general phenomenon approach is suitable. Furthermore, when research questions include the word “How”, as in “how is something being done” it’s most likely that a qualitative instruments is better suited in opposition to a “how much” type of quantitative question. However, comparative studies using qualitative interviews have to be done carefully using analytical frameworks that are usually quite different from testing hypothesis about general differences between groups. Moreover, interviews can be a good option if direct observation is not possible but the provide indirect information filtered with the interviewees’ perspective and the presence of the researcher may motivate bias responses (Creswell, 2009).

The qualitative interview was selected for this research for the type of data that can provide to the discussion. Given the topic of human interaction with a technology together in a working environment, a qualitative approach was the one selected to provide an exploratory path to a complex phenomenon related with social sciences. Moreover, the selection of one case study and data collection by observation would probably not answer the main research question when it comes to the external interdependencies between organizations that take part in the design process and software technology implementation.

This qualitative research was conducted with interviews in the selected offices with BIM users, both architects and engineers, business owners, and software developers/sellers, as shown below in the interview list (Table 1).

N. º	Type of company	Company Code	Function	Person Code
1	Architecture	SA1	Building Engineer	Engineer#1
2	Architecture	SA2	Architect	Architect#1
3	Architecture	SA3	Building Engineer	Engineer#2
4		SA3	Arch Business Owner	Architect#2
5	Architecture	SA4	Arch Business Owner	Architect#3
6	Architecture	SA5	Architect	Architect#4
7	Software	SC1	Managing Director	Software#1
8	Software	SC2	Sales representative BIM specialist	Software#2

Table 1 – List of interviews and companies

For this purpose, a semi structured type of interview guide (Appendix 1.) was created and divided into three themes in the following order: The individual perspective, the office perspective and the institutional perspective.
The first perspective, *the individual*, has the purpose to recognize that the source of information is an indirect one and that in certain issues that BIM perception will become very much personalized. In these is included the perception that one has on a given technology. Here, the first questions are intended to provide easier and introductory answers to build trust and motivate the interviewee.

The second part of the interview guide, called *the office*, is related to the challenges and drivers of BIM implementation in small architecture offices and focusing primarily in the interdependencies between those and the internal management aspect of the office activities. In this section, two structured multi choice question were included where the interviewee must rank a pre-selected set of challenges and drivers to BIM implementation in that office. This type of question was designed with the intention of facilitating and summarizing answers from the interviewee and worked well in this sense. On the other hand, it has the downside of maybe narrowing down the answers even if the option "please name others" is included.

The last part, *the institutional perspective*, is connected with the selected theoretical lens and was design to aim at the perception that the interviewee has on how different institutions influence BIM diffusion in that office and which isomorphic pressures can be identified in that particular inter organizational context. In this last section the questions were design to be more open to provide longer answers when a sensation of trust and easiness has been established between the researcher and interviewee. Some of the more interesting thoughts were actually provided in the "other comments" final section, when the interviewee was feeling more at ease.

3.2.2 Data analysis and coding

Previous to the data analysis, criteria were established to the transcription of the interviews. This allowed for different persons to perform transcriptions of the collected audio data using the same format of writing and which information to summarize and which information to collect for quoting purposes. Moreover, the transcriptions were performed in shared online documents, which allowed for shared coding after accessing each team member's code inquiry and agreed on possible overlapping. The fact that the codding was done in a comment section of an online shared document allowed both coordination and fast scan through all the interviews in different tabs of the internet browser. From reading the whole data collection and coding it, different themes were produced.

For the structured multi-choice questions analysis two methods were selected, producing to different graphical results contained in the empirical data section. In one table, a percentage was given to the answers given to the highest rank, for both challenges and drivers for BIM implementation (Table 3 and 5). In the second method, a point system was attributed to provide more differentiated results, containing all the answers to all ranks where the highest ranks were given more points (Table 2 and 4).

3.2.3 Validation and reliability

Qualitative validity means that the researching team checks for the accuracy of the findings by establishing certain procedures, while qualitative reliability indicates that the research approach is consistent across different researchers and different projects (Gibbs, cited in Creswell, 2009).

For that purpose, bullet proof reading of all transcripts was performed by every researcher. Moreover, in every quote the minute of the recording was included to allow to further inquiry and validating the collected data. In addition to that, an intercoder agreement was set in place to ensure that the meaning of the codes was understood by all researchers and two different codes could be used in a same passage of text (because that they relate to both themes). Moreover, triangulations were made between different sources of information to build a coherent justification for themes. Finally, different informal peer debriefing sessions were conducted with another group of researchers besides the scheduled formal opposition sessions.

3.3 Ethical considerations

In this research the anonymity of the companies and interviewees was guaranteed and expressed in the beginning of the interviews. While requesting the permission to voice record for only use by the researchers for data analysis. In the interview list (Table 1) while it is important to provide the function of the interviewees, the names of the persons and companies are protected. Moreover, it was a main concern to promote a sense of trust and non-disclosure with the interviewees and promote a sense of integrity and authenticity in the present study.

Furthermore, while designing the interview guide and conducting the interviews, some ethical issues have been anticipated since some of the interviewees might work in the same company and some companies might be competitors. Furthermore, the thesis proposal and the interview guide were sent to all interviewees with one week in advance, so they can get acquainted with the questions and topic. These measures were made to providence guarantees to the interviewees on the type of research being carried out and moreover to guarantee that there would not be any question addressing some conflict of interest, invasion of privacy or sensitive data of the selected company.

4 Empirical Data

4.1 Perception of BIM

The collected data suggests that there are two different groups when it comes to the perception of a BIM concept in the interviewed small architecture offices. The first group is working with BIM mainly as a design tool. However, this first level of BIM is also recognized as standard by some of the interviewees or not even considered BIM at all, as BIM in a higher level would require to insert more information into the model, which we relate to a second group of interviewees.

4.1.1 BIM as a design tool

The first group sees BIM more as a design tool, Engineer#1 states that in that company they have the standard process of building a 3D model and doing clash detection, but they still do the model with CAD. In this perspective, BIM is a process that doesn't depend on the software tools that are being used since CAD is used as BIM. Engineer#1 states that BIM definition is a nebulous process and that there is no point and trying to define it because it can always be different from person to person.

However, others have a more objective and practical view of BIM, even if they haven't worked with BIM before or if they aren't working with it directly: *"BIM is for me a way to work and can give you information about items when you're developing projects"* (Architect#2); *"You work with objects instead of lines. It's a realistic representation of what you're trying to create."* (Architect#3). Moreover, Engineer#2 describes BIM referring mostly to the visualization possibilities, not only for the client, but for the benefit of the design process itself.

4.1.2 BIM as a collaboration / management tool

As for the second group, BIM definition is related both with Building Information Modelling and Building Information Management. Architect#4 defines BIM as an administrative tool to manage collaboration between disciplines and information in the model in the last design stages. Architect#1 defines this higher level of BIM as another layer of information that is added to the model where you have to classify every element in it, decide which materials are used where and how they make the connections between materials, for example. Furthermore, Architect#1 exemplified how BIM is being used as a collaboration and communication tool by opening a BCF (BIM collaboration formal) file that contained messages/comments aimed automatically to specific elements of the model. These interviewees are working with projects that use BIM in a deeper extent, with budgeting and procurement procedures but also with energy efficiency targets that are calculated in early stages of the design providing feedback to the architecture team so they can make adjustments (Architect#1).

4.1.3 BIM definition by the software companies

Software#1 started the answer with *"Besides the Christian faith BIM is the most diffuse term of the world"* which sums the definition of BIM pretty good up, because everybody has a different perception. BIM is in his experience more than CAD it is the connection between the 3D model with time and cost estimations. This provides the possibility to build the building virtual and to plan each step from scratch till the end. In the execution face it is then possible to compare the virtual model with the reality. Moreover, he sees BIM as a tool for collaboration. Software#2 is stating that *"BIM is all about Building Information Modelling and Building Information Management."* They see it as a methodology to collaborate in interdisciplinary work in the construction industry. It should not be seen as a modelling tool, it is more than that.

4.2 Challenges and drivers in BIM implementation

In this section we are going to investigate how the internal factors can influence the BIM implementation, moreover why and how it is taking place.

4.2.1 BIM requirement

From the broader perspective every single office is aware that BIM is sooner or later taking over the industry. As Architect#3 is stating *"It is becoming more and more a requirement"* However, even though it's developing into a general requirement, each of them is approaching the BIM implementation differently. Software#1 is adding that the demand is not high enough for smaller companies yet, but *"it's just a matter of time, they know that they will move forward someday."* Moreover, the size of the company is of matter as well because, *"The larger the size of the company, the larger complexity of the whole BIM implementation."* (Software#2).

BIM usage is also depending on the age of the building or project. The pressure going for BIM is getting higher when a new building is getting constructed (Architect#3). Architect#4 is stating that sometimes they were not able to work within BIM because the projects began some years ago and the files had an old format. Architect#2 is stating that *"I think architects are talking a lot about programs but not so much about architecture. And all the clients they know that we can do so many things with our program and then they demand more and more and more."* It seems like that a lot of clients think that BIM is the solution for all the problems, but at the end the performance of the architect still counts as the most.

Most of the employees are open for BIM and open for further investigations in implementing it. The demand mainly comes from the outside, even though there are some intern influences as well for example when it comes to looking for new employees. If a company wants to hire young professionals, the company should provide a modern working environment, because the demand is getting higher from the “younger” generation. This includes having or using BIM to a certain extend. Architect#2 sees this as an opportunity for the company to develop *"So, when people come into the office I try to understand, ok why this person wants to work like that? Ok we try it.”* Through this approach they have already been able to benefit from it in different projects. New workers from school which are familiar with BIM are faster and more efficient than the older generation and you can quickly assign them into tasks (Architect#4). Moreover, there were clients which came as an individual to the software company#1 asking how the BIM implementation could take place in their office (Software#1). This got supported by the statement of how Engineer #2 is pushing the company to use BIM for all future projects *"Yes, that is like one of my objectives for this company, is that we use BIM in all projects.”*

The upper management is the one who is steering how the implementation should take place and till what extend. There are different kind of approaches from the companies. Some of them sees it as necessary to send each employee to BIM workshops and others just go for a few, which then are functioning as mentors for the others. On the other hand, according to Architect#4, only more projects can improve the handling with BIM *"You can go to a workshop but then you maybe learn 2*%." (Architect#4). There are different kind of perceptions when it comes to BIM workshops. According to Engineer#1 there is no need for somebody to come to their office holding a sales pitch *"they should talk more about the technical aspect"* and which functions to use. Moreover, it seem that in each office the education is taking more internally place, which means that thy are helping each other is stating that the education is mostly taking internally place which has also been seen at the other interviews (Engineer#2).

4.2.2 Challenges implementing BIM

In this section we are looking at the challenges of BIM implementation we have gathered out of the interviews. A point system was attributed to provide more differentiated results (Table 2), containing all the answers to all ranks (higher ranks getting more points).
In the second method (Table 3), a percentage was given to the answers given to the highest rank, for challenges in BIM implementation.

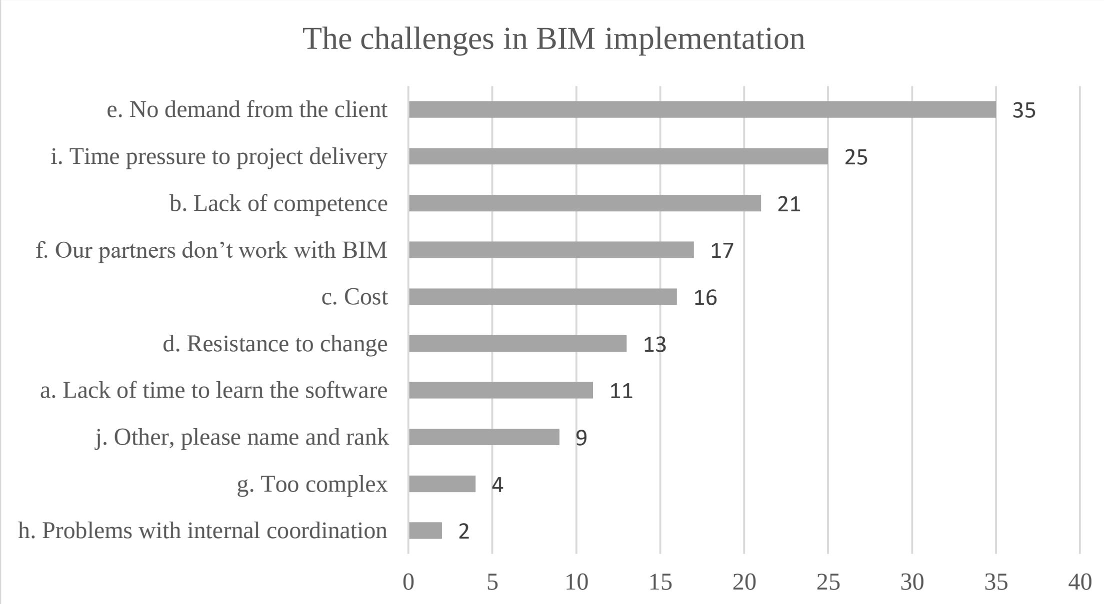

Table 2 – Answers for the challenges in BIM implementation, points given according to ranking given by the interviewees

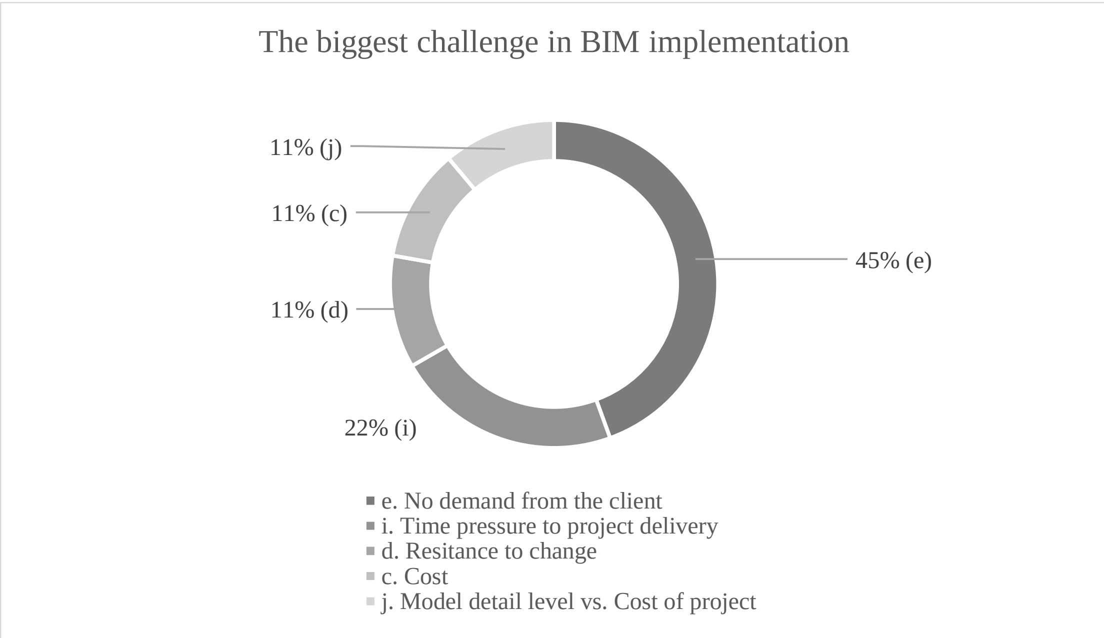

Table 3 – Answers for the challenge in BIM implementation ranked in #1

According to the data, the factor *"e. No demand from the client."* got ranked as the biggest challenge in BIM implementation. As Architect #3 is stating that *"most clients don't want to put any extra money on BIM."*. Engineer #1 argument is supporting the statement by saying that if there is no reason for change they will stick with autoCAD. Implementing BIM would require *"learning new programs, setting up new templates and so on"*. Through the years they have developed a CAD-system with templates which had to be converted, this considers a lot of time and work. According to Engineer#2 the demand for BIM also depends on the company and the projects they are working with *"because in other offices they are working with bigger clients and they also demand".* Compared to bigger companies, smaller ones don't have the same pressure yet from the building industry, but it will sooner or later catch up on them (Software#1). Moreover Engineer#2 is adding that the company by its own is too young so they don't have that many projects where it is relevant to use BIM yet.

The following ranked challenge is *"i. Time pressure to project delivery"* which is a bit related to *e.* because BIM usage considers more time in the designing phase than the regular way. "*If we are talking about BIM, we are often talking about putting more information into a model, which means that it consumes more time. So, in the early stage of the project they do sketches on 2D and later on when delivering the project the come up with exporting everything into 3D."* (Engineer#1). This is something the client does not want to pay for which drive them to discard BIM. Architect#2 is supporting this statement from the design stage point of view by saying that *"When we know what we want to do we do it in Revit."* since they are also using a more user-friendly software in the beginning of the project. Even though BIM consumes more time to deliver a project the company SA2 is very positive towards BIM but they also need a customer that is willing to pay for it. Another point of view is that BIM is also seen as a complication for certain type of projects, because simple processes are getting complicated (Architect#3) and slows you down (Architect#4).

"b. Lack of competence" has been considered as the third biggest challenges when it comes to BIM implementation. As Architect#1 is stating sometimes the contractors, also big contractors, don't even know what is meant by going for BIM and ask for advices *"because they don't really know what they are asking for. They only know that they also want BIM and then they ask us!"* If BIM should become a success it is important that it gets used continually otherwise the gained knowledge will disappear, because *"It is not so much about the software, since it can be leased. It is more about developing the competences in the office and keeping them updated. If they just would do one this year and maybe the next year they will forget. So, it has to be consistent."* (Architect#3). There is also a lack in the management area when it comes to competences, because mostly they do not directly deal with the product they are buying. They are basically just having the costs in their mind which provides difficulties seeing the benefits that comes with the product (Software#1). Moreover, this statement gets underlined by the CEO of company SA#2 which is aware of that the importance of software is increasing but the architect feels anxious about losing the control over the models because the CEO will not be able to change or check something according to the knowledge which is missing. On the other hand, BIM gives the company the possibility to go for bigger projects, but this increases the importance of competence in BIM. *"If we get a big project now for example, there will be a big workload for some people and the rest will try to help but they will… struggle and they will be sometimes a burden as well. And it is also costly because they are very slow."* (Architect#2).

The fourth biggest challenge is *"f. Our partners don't work with BIM"* which has been ranked. According to Engineer#2 they had projects where a few of the disciplines did not work with BIM moreover clash detection which lead to internal problems, because they were not on the same level. This lead to a lot of problems during the construction because clashes were detected too late and provided a lot of costs. Architect#4 is stating that he has the feeling that they are the only company working with BIM which lead to a decreased motivation for investing more time into BIM. Moreover, the reason why the others do not go for BIM could be the same as the company complains about. Nobody wants to change their working processes or templates which has been developed through the years (Engineer#1). Architect #4 was facing a situation where it was not even possible to work with BIM, because the project they were working in started in 2004. This led that all the drawings etc. were made with CAD. It would have taken a lot of time and money to convert all these drawings into a BIM model.

When it comes to *"c. cost"* there are different opinions on how they get handled. According to Enginieer#1 software can get costly, when there is a need to have several software's to fit the different kind of client's demands. The software company#2 is supporting this argument by saying if the company is not using BIM at all, costs are the biggest challenge in their opinion, because it's a big investment in the beginning implementing BIM. Company SA4 mentioned that the costs where sometimes the reason why they went for BIM in a project, because they have bought these expensive licenses and now it should be used. On the other hand, according to Software#2 there is a possibility to sell the license again after buying it to another person or company. Software#1 is providing different kind of packages which are customized to the current situation the company is facing. From the clients' perspective the project costs are higher in the early stages of the project compared to the regular way, but it pays of at the end according to Architect#2 *"So for the client it's much more cost, you will get it back when you start building, because you have less problems when you have more control of the product."*.

According to Architect#3 *"d. Resistance to change"* is the biggest challenge, because all the work processes and templates must be revised. Older companies have their ways of working moreover templates of how to work and approach projects. In case BIM gets implemented they must change everything related to BIM, which consumes a lot of time and money. Software#1 came up with an argument which is a bit connected to *"a. Lack of time to learn the software"* but according to software#1 the problem does not rely on learning the software. Implementing BIM is about 20-30% learning the new software and 70% of it is implementing new processes and new ways of working and thinking. So just having the software doesn't help. Furthermore, the complain that there is no time learning the software got brought up often as well, but according to Software#2 there *"are no best times or seasons in the year to adjust to a new way of working, it always takes some effort and disturbance."*.

4.2.3 Drivers implementing BIM

In this section we are looking at the drivers of BIM implementation we have gathered out of the interviews. A point system was attributed to provide more differentiated results (Table 4), containing all the answers to all ranks (higher ranks getting more points). In the second method (Table 5), a percentage was given to the answers given to the highest rank, for drivers in BIM implementation.

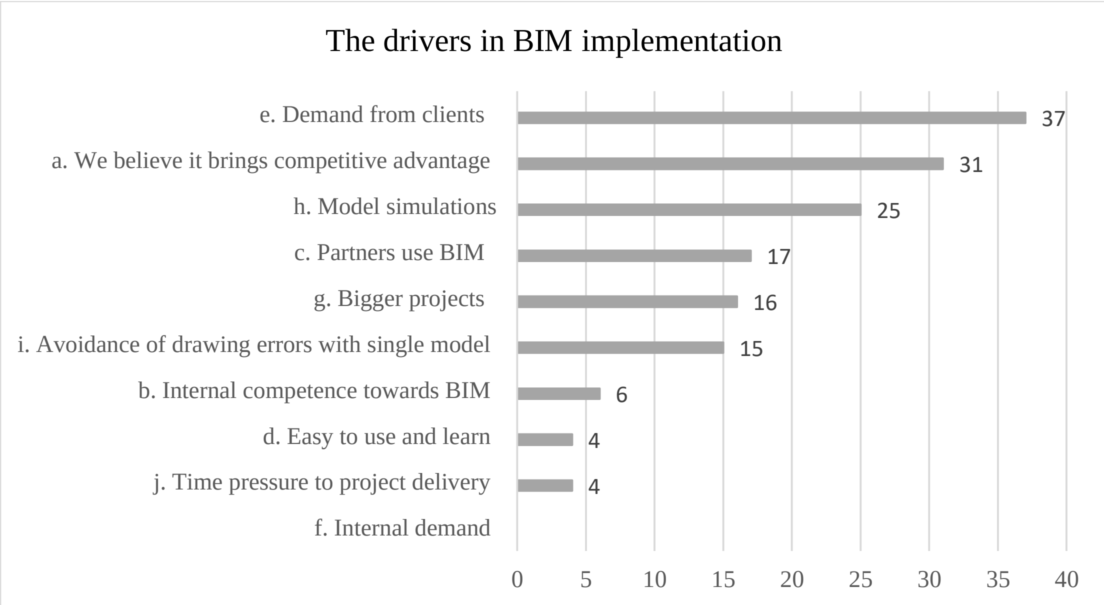

Table 4 - Answers for the drivers in BIM implementation, points given according to ranking given by the interviewees

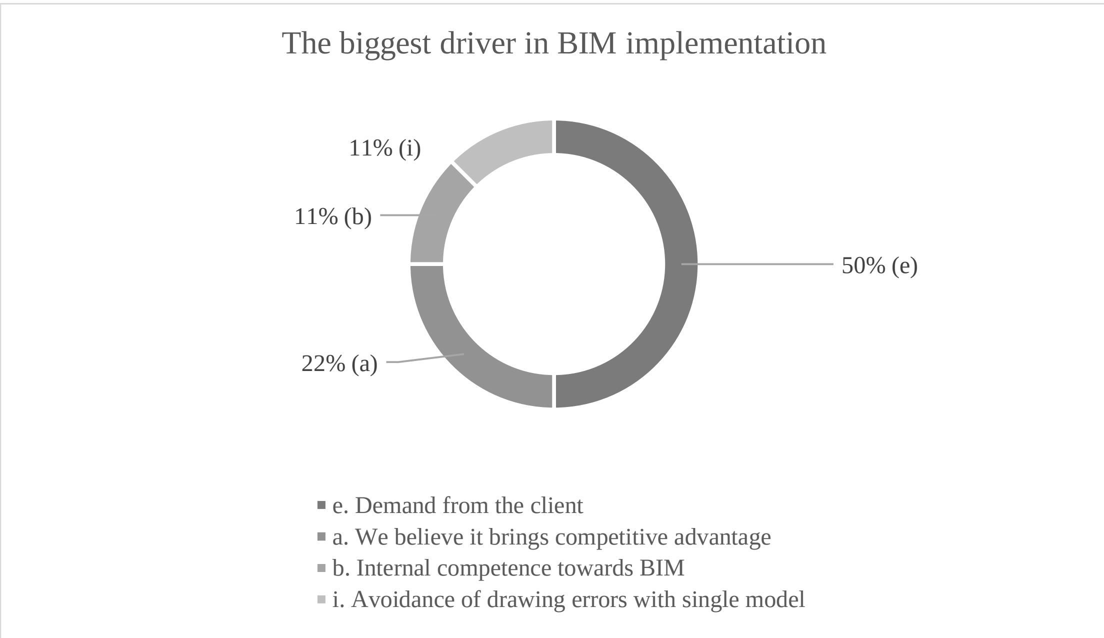

Table 5 - Answers for the driver in BIM implementation ranked in #1

"e. demand from the client." got ranked as the biggest driver for BIM implementation. Architect #4 states that *"If the demand wouldn't be there we would stick with CAD."*. Furthermore, he states that *"The client and money issues were actually the driver for BIM, because they had to have it as efficiently as possible."*. The pressure for becoming more efficiently regarding costs, time etc. gives the client no other choice then going for BIM. The client is following the market which wants to become better and more efficient. Moreover, smaller clients are following the bigger clients to be able to stay competitive (Engineer#2). According to Software#2 every company will somehow go for BIM the last ones will be the ones with senior architects, *"but they will eventually also retire.*"

The second biggest driver ranked was *"a. We believe it brings competitive advantage"*. According to Engineer#2 *"I think it brings advantage for sure, as I have been working with both CAD and BIM and the efficiency that it brings"*. It gives you the possibility to learn from the other disciplines as well, because you see how they work and adapt to the model. Moreover, the single model forces the disciplines to collaborate on a positive level, they learn from each other and are having a better communication. This gets supported by Software#2 because you get a sense of collective if you're working in a model with other disciplines. That means that you have a better sense of each other's work and problems and you're more open to solutions.

On the other hand, Architect#1 is stating that they don't think that they have a competitive advantage against the other offices having BIM, because the most of them works with it. In the end it is all about delivering a good BIM model to the client. Implementing BIM in a smaller company can be of advantage, because the internal coordination and problem solving is much easier than in bigger. BIM also provides the possibility to become more efficient according to waste and time usage. Moreover, it let us work in a more sustainable way (Software#2).

According to the ranking *"h. Model simulation"* has been ranked as the third biggest driver. The benefit of being able to test the model is the possibility to make changes in an early stage of the project (Architect#1). Moreover, Enigneer#1 is stating that *"I think it's a good tool also for internal coordination"*. Software#1 is mentioning that in every industry the cost security is of a big importance, which can get provided through the BIM model. There is a new insurance company named PCI it insures that the costs of a BIM model which has been provided is covered by them. In case the price exceeds the contract, they will pay up to 30% above the agreed amount of money. Furthermore, Software#1 is mentioning the possibility of calculating the quantities on materials for a project in advance is bringing a huge benefit for the client.

4.3 External influences on BIM diffusion

4.3.1 Public institutions and standard formats

In this section, the data collection gives evidence of some of the inter-organizational dependencies and influences on small architecture offices. The Swedish construction industry, as mentioned before, is characterized by a strong influence of the state, whether by issuing regulations or by acting as an influential client in infra-structures and public construction developments. However, the collected data shows that, of the five small architecture offices, only SA1 referred to have been working with a public client.

Moreover, there were several interviewees expressing their opinion about standard formats that are demanded by public clients and they demand to small architecture offices. Enginner#1 expressed a positive opinion from the open BIM requirements by Gothenburg city since they don't demand any specific working file format, if it can be converted into a 3D IFC standard file format. In this way, since SA1 does not work with any of the more recent BIM software tools, it continues with the same tools and methodology, as long as it reaches the client's expectations. Architect#1 expressed positive feedback towards the demand of a 3d model in IFC or another format but also referred the importance of 2d drawings, since it contains some text in the drawings. Furthermore, a similar positive feedback towards a standard 3d model format:
"At some point I guess a transition is needed. At some point we need to maybe move ahead, and instead of delivering hand drawn drawings, move into DWG and then maybe into IFC. I mean I guess there is a natural development." (Architect#3)

4.3.2 Professions and BIM

All interviewees were very consistent and confident when they answered that the Swedish architecture association did not have any noticeable influence in that office when it comes to BIM. Moreover, like Engineer#2 pointed out, there is sometimes the perception that the engineers should be working more with the BIM model because they normally are more connected with the production of the drawings in the last stages of the design process. While other offices sometimes have an architect, who is responsible for the BIM model. In addition to that, Engineer#1 refers that in that office architects are more responsible for the aesthetics of the building while engineers are more responsible for producing the drawings.
However, Architect#1 and Architect#4 were responsible for BIM models that were delivered to the client, where normally an in-house or consultant BIM coordinator assesses and manages the information between disciplines. Other architects express the quality or architecture as being a goal that go beyond or parallel with the methodology or the software tools.
"I think architects are talking a lot about programs but not so much about architecture. And all the clients they know that we can do so many things with our program and then they demand more and more and more." (Architect#2)

Engineer#2 referred to education institutions as an influence in BIM diffusion. Since the graduated students will have specific demands and motivations towards this technology and they expect those to be met by the employer. Moreover, the influence on a personal level was also produced by the big construction companies in big seminars.

4.3.3 Main external influences in BIM diffusion

The collected data shows that the main external influences for these small architecture offices are the client and then the partners that work or don't work with BIM. Engineer#1 stated that they will continue with their work processes and same software tools until they have clients that demand for BIM as more than a modelling tool. The same goes for their partners that mostly don't work with BIM in a higher level. In this case it seems that there is no strong internal motivation to move to another working process and new software tools. A similar situation is described by Architect#3, which referred that one of the main reasons because they are still not implementing BIM is because the client doesn't require that.

On the other hand, some offices report the existence of client demand for BIM as the main driver for BIM implementation. Architect#4 states that if there was no demand from the client they would probably still be working just with CAD. Moreover, the first BIM project in the company was done because of client demand with the aim of not going over budget in the construction phase and increasing efficiency through the project phases. A similar and proactive position is described by another interviewee: *"If you are in my position and you make the structure for the work of a team, then you can make a decision of what is the most efficient way for us in this project. And if you think you get benefits from working in BIM you can also inform the client of that. And maybe the client can agree and say, "Ok let's spend some more time to make this a better product"* (Architect#3)

4.3.4 BIM and the project approach

Some interviewees also reported that BIM implementation has changed or would change their project approach and the way that office is positioned in the market. Architect#3 states that implementing BIM would require a redesign of the business strategy since they are specialized more in one type of project and the contacts that they have get them projects in that area. Going for BIM would increase their range of project, but it would also require a change of working processes and strategy in the company and contracts. Architect#4 says that BIM is allowing the office to go for bigger projects that they wouldn't get if they hadn't started to implement BIM in the first place. Moreover, regarding the competitors and the resemblance in different offices: *"We noticed that office X is doing that, so we should look into that as well. It's going to be* *hard for someone to come up with something unique which all the other offices don't have"* (Architect#4)

On the other hand, some interviewees in small architecture offices detach the tools from the business strategy. Engineer#1 is supporting this statement by saying that their client approach is very much based in close personal relationships of trust and developing a BIM methodology would not change that. A similar approach can be found in SA2: "*We try to find clients that have the same ambitions as us and that is not necessarily connected to the price of the building but more with what kind of freedom the architect has to create within that budget. Then that is a very attractive project. Otherwise they would not need us if they have a software where they can put all the parameters and a building would come up"* (Architect#1).

5 Discussion

The discussion is carried out in the following three subchapters, following the structure of the collected empirical data and confronting it with the theoretical framework. In this way, a general overview of how BIM diffusion is developing in small architecture offices in Sweden is provided while comparing results with theory. Perception of BIM presents the different definitions and understandings of BIM. After that, identified challenges and drivers are discussed. Finally, the external influences on BIM diffusion present the findings while looking through the institutional theoretical lens.

5.1 Perception of BIM

After gathering the data from the interviews, as Aranda-Mena et al. (2009) already stated, there were different opinions about how BIM could be defined. Although there is evidence that BIM technology increases efficiency and decreases the actual drawing work load (Hardin, 2009; Glick and Guggemos, 2009), BIM has created new services and data that can be used into project management, cost estimations, energy efficiency simulations and others. This has created a new kind of workload for the architect where every element has to be clearly classified following the BIM requirements of the client, including all the materials and connections between elements. This becomes hard to do when there in an early stage of BIM implementation because of reported challenges such as lack of competence and time pressure to project delivery. For this reason, alongside with complexity of tool has been stated as a reason not to use BIM model in the early stages of design or to make a new clean model with the correct information when going into the DS (Design Stage - Systemhandling). The statement here would be that of the design stage becoming heavier in terms of work load to benefit the production and operation stages of the full lifecycle. On the other hand, the lack of BIM competence in designers that are learning the technology could be the most influential factor adding time and costs to the design stages (Matta and Kam, cited in Haliburton, 2016).

However, everybody agreed upon that BIM can be seen as a designing tool and furthermore as a collaboration tool. Therefore, from the group of companies that are already implementing BIM, the technology was primarily used as a design tool. This is connected to what Bryde et al. (2013) was stating because BIM technology gives everybody who is involved in the project the possibility to receive/produce photorealistic visualisations, walkthrough and animations. This makes it easier for everybody to understand and moreover it reduces the risk of misunderstandings in the project. Furthermore, the possibility to characterize the geometry, spatial relationships, geographic information, quantities and properties of building elements (Bazjanac, 2006). One of the companies is taking it one step further adding information to the objects, because it sometimes requires a tool which can already contain architectural information from the beginning (Ham N. et al., 2008).

On the other hand, BIM got mentioned as a good tool for collaboration. As Hardin (2009) states that it encourages the integration of the roles of all stakeholders in a project. Moreover, it lets all the disciplines learn from each other, because they are able to see how the others are working. Furthermore, the perception of BIM is aligned with Demian & Walter (2014) who found out during their study that the participants highlighted the core potential of BIM as a provider for a better collaboration and communication between the disciplines.

According to the software companies the definition of BIM is very wide among their clients. They are stating that the software is just about 30% and the other 70% is about making changes in the workflow and project delivery processes which is aligned with the argument from Hardin (2009). Moreover, something which has not got mentioned that often is BIM is also including time and cost estimations (Azhar, 2011; Bazjanac, 2006) otherwise the definition is pretty much the same.

5.2 Challenges and drivers in BIM implementation

The general interest going for BIM is because the building industry is trying to get more and more efficient. This craves being better in collaboration and communication (Eastman et al., 2011), along with becoming more sustainable regarding waste and material usage (Azhar, 2009; Maltesea, 2017). In some cases, BIM is not even necessary depending on the projects the company is currently working with. As an example, one of the companies we interviewed is mostly working with retails in big shopping malls which does not require BIM, because the level of detail is not that high and data base is in CAD format. Even though it's working fine for them now they are aware of that it will sooner or later become a requirement. Furthermore, there have been issues with some projects, too old for BIM adoption, because BIM is leaving the traditional paper-based work (Lee, 2008) and some of the older projects are still only working in the old traditional way. It would take too much time to redo all the documents according to the BIM standards.

BIM is giving the small architecture offices the chance of working with bigger projects because "*the coordination of complex project systems is perhaps the most popular application of BIM at this time. It is an ideal process to develop collaboration techniques and a commitment protocol among the team members*…" (Grilo and Jardim Goncalves, cited in Bryde et al. p. 972). A downside which is named in the interviews, is that it sometimes feels like architects are only talking and working inside of the software. They are losing the ability to have a free mind-set, instead they are sitting in a golden cage having the software as a boundary. Another issue which is mentioned is that clients get influenced by seeing all the benefits what software can do and demand more and more, but in the end the architect is the brain behind everything. Just having the best software does not mean that it can deliver well planned and designed architecture.

There were different approaches on how BIM is being implemented in the companies. According to the theory of Kirby (2007) there has to be a BIM implementation plan right from the beginning. Furthermore, they must be aware and not afraid of changing their current working procedures according to BIM. Most of them were complaining about that they did not get out that much from the software educational workshops. The complaints were related with having just a sales pitch instead of more technical and tangible benefits or just learning 2% after performing educational workshops.

According to Matta and Kam (2010) there are six steps of how to adopt BIM into the culture of a company correct, just hiring somebody from a software company is not the right approach. Furthermore, "*the cultural transformation of an owner organization's human capital is key to successful BIM adoption*" (Matta and Kam cited in Haliburton, 2016, p. 20). One of the companies we interviewed considered this by looking at the individuals and seeing their strengths and trying to let the whole organisation benefit from it. Moreover, the BIM learning process took place more from an internal position (for example with BIM specialists of mentors) in every architecture office, which again underlines the importance of the human capital (Lu & Sexton, 2009; Matta and Kam, 2010). The approach of just sending a small number of employees to a professional BIM workshop proved to be more beneficial than just having somebody in the house for a certain number of hours. These then worked as mentors for the others and were responsible for letting the others know. In this sense the learning outcome was better when it took place internally.

Another benefit which comes along with BIM besides time, costs and material saving is the ability to calculate all the quantities needed for the project/building and becoming more efficient (Azhar, 2011). This gives the users the opportunity to save materials on the long run, which indirectly delivers a more sustainable building industry. Moreover, it is possible to take it one step further and use Green BIM for energy performance evaluation and sustainability assessment. Therefore, by doing revisions the designers can make sure that the contractor gets what he demands according to his green ambitions (Maltesa, 2017).

The main challenges what we have gotten out of the interviews are equal to what Elmualim & Gilder (2014) and Kam (2010) have come up with. BIM implementation has to be seen from a broader perspective not only be seen as a software which is getting implemented (Kam, 2010). Elmualim & Gilder (2014) named three major challenges which are pretty aligned with our outcome: "*training staff on new process/workflows; effectively implementing the new process/workflow; and understanding BIM enough to implement it*" (Elmualim & Gilder, 2014, p. 197). Furthermore, Barlish & Sullivan (2012) had an equal study about ranking the challenges implementing BIM whose results are generally aligned with the ones for this study. However, the factor "no demand from the client" was not getting mentioned, in contrast to the biggest stated challenge in this study. The clients are not willing to pay more as long as they do not see a clear ROI which is consistent to the theory of Barlish & Sullivan (2012). According to Barlish & Sullivan (2012) most of the clients do not think strategically.

Furthermore, the companies and clients that have been established for a longer time also have more consolidated working processes, office cultures, software tools and templates that they are working with. These can be seen as some internal barriers because going for BIM means changing all the consolidated working processes even more reconstructing drawings from older versions to new (Bryde et al., 2013; Barlish & Sullivan, 2012; Elmualim & Jonathan Gilder, 2014). The companies that show more resistance to BIM have been found to have a pattern of well-established position in the market for more than 10 years, a slow rate of growth and in the case or a specialization in a particular type of architecture project, a niche market. So perhaps these companies have their own clients which are not so keen in changing technology because it does not bring any particular benefit to them. Even though that the smaller companies do not have the same pressure as the bigger ones, everybody is aware of that it will sooner or later become a requirement. Another issue which was brought up is spending extra time on creating the model. In certain types of projects, BIM can also be seen as a complication, because the processes are getting more complicated and time consuming (Bryde et al., 2013).

According to the statements from the architecture offices some clients think that BIM is the solution for all their problems. So, they demand it but do not know what it is and what it requires to work with it. Which again is consistent with the outcome from Elmualim & Gilder (2014), because before being able to use BIM there has to be an understanding about what it actually is. Furthermore, there is a lack of competences when it comes to using BIM as a new software, which gets underlined by the statement from Bryde et al. (2013). If a company does not have the right competences it is difficult to implement BIM on a long run. The statement that their partners don't work with BIM has not been brought up during any theory. In speculation, this could have been influenced the small architecture companies by having an "excuse" for not going deeper into BIM, because nobody else is working with it.

Moreover, the upper management mentioned a few challenges about anxiousness of losing the control of their projects which is connected to the study from Barlish & Sullivan (2013) in point *"(5) users may feel intimidation or fear of the new system and how it will affect their jobs negatively;" and "(2) organizational changes may occur as a result of the introduction of a new system*;" (Barlish & Sullivan, 2013, p. 154). On the other hand, some of the interviewees are stating that the upper management only has the costs in their mind and do not think that much about the benefits of BIM. However, this should not be a reason to avoid BIM, because according to the software companies there are packages which can get customized to the current situation of the company. This includes that costs can get kept to a minimum moreover the possibility to sell the bought licence to another user.

When it comes to the drivers of BIM implementation, results are equally aligned to Eadie et al. (2013). Even though the study was different from its approach and methodology, they were having bigger companies etc. the outcome was surprisingly equal to ours. The only bigger difference in the ranking system was that Eadie et al. (2013) study was a bit more in detail the answers, our answers were broader than his. In our study the biggest driver for BIM was pressure from the client which in Eadie et al. (2013) study landed on the 6th place. According to our interviewees if the demand would not be there from the clients' side they would stick with AutoCAD, but saving costs and becoming more efficient is getting a big driver for the clients which indirectly influences the architecture offices going for BIM. One of the bigger drivers in both studies was that companies believe in a competitive advantage or moreover the competitive pressure has been seen in the top three drivers. This according to Liu et al. (2010) should be the biggest driver especially in architecture offices (Coates et al., 2010). The next biggest driver is clash detection and model simulation. BIM is a good tool for solving issues in the early stages of the projects (Azhar, 2011). Another benefit using BIM was the internal coordination through the BIM model. "*The realistic sequencing and costing of construction works, saves significant time and money through reduced rework and delays to programme*" (Azhar, cited in Eadie et al., 2013, p.342). On the other hand, younger companies with a faster growth rate have been found to be more open to new tools and technologies and have an office culture of keeping their tools and hardware as much as possible up to date. Those companies also do not have a decade of consolidated working processes and templates. In addition to that, they employ straight out of college professionals that are very pro-BIM and have their own motivations and development objectives. So, there is a possibility that the types of clients they are working with belong to different group of clients.

5.3 External influences on BIM diffusion

Through the collection and analysis of data, evidence was found on how organizations act and are acted upon, shaping themselves and others through processes of institutional isomorphism (DiMaggio and Powel, 1983). This means that the selected small architecture offices strive not only for efficiency on a resource-based dependency model but that they also act and are acted upon when it comes to BIM adoption on partners, clients and public authorities. These results are aligned with the ones attained by the study performed Cao et al. (2014) in the Chinese construction sector, where isomorphic processes have been found to influence BIM adoption in significant way.

Although these companies, due to their size and nature, not often work with the state or public clients, they identified indirect *coercive isomorphic processes* on a lower scale and through bigger clients, often construction companies that have the state as client and they set up their own BIM requirements for the architect companies working as consultant companies.

The existence of extensive and non-standardized BIM requirements has proven to be an instrument (and sometimes a burden) that shapes organizations through the tools and working processes that they are obliged to follow.
The demand for a standard format in public clients (namely IFC format) can be identified as a coercive process that acts as a driver for BIM diffusion in small architecture offices as well. This requirement is seen by the selected companies as a positive influence since it allows companies to choose their own tools if the result is convertible into the required standard exchange format. This provides diversity of working processes and tools that can be used to achieve the same expected result. However, some of the results also show that there is a general perception that the state and the municipalities could be working more together to set up BIM and standard format requirements or guidelines that could be used nationwide.

Results on the data analysis are also consistent with those from Cao et al. (2014) when it comes to normative pressures since they have not been found to exist on a significant level when it comes to the architect's professional association. However, normative pressures have been found to be significant when it comes to educational institutions. These, along with major ACE companies, provide courses, seminars and web seminars that have a strong impact in BIM diffusion. In addition to that, this normative isomorphic mechanism works in a way that new formed architects and engineers have their demands towards the employer when it comes to working with BIM. This employee, after integrated into the company carries on by disseminating an internal demand (Fig. 3 below).

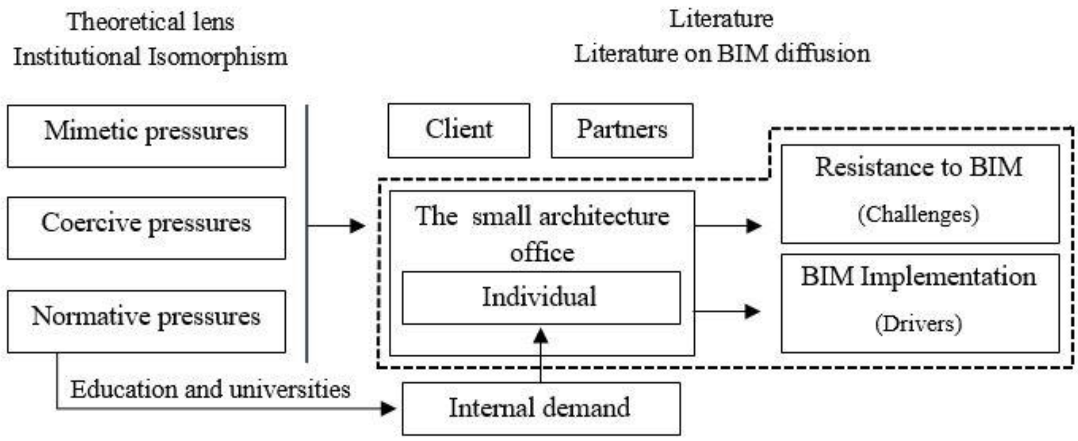

Figure 3 - Diagram on BIM diffusion in small architecture offices for this study

Mimetic isomorphic pressures have been found to be of lower significance. However, results also show that architects, engineers and other professionals are exposed to mimetic influences without the presence of the client (Cao et al., 2014), whether by partners or others, this does not seem to be a crucial motivation towards BIM adoption. Several hypothesis could be presented to explain this phenomenon being the influence

and demands from the client the biggest one, like explained earlier in the finding subchapter.
In addition to that, in some cases the BIM users also found themselves in the position to influence the client. However, the success of this influence also depends on the BIM competence of the client and the willingness to invest for a higher-quality design product that can increase efficiency and sustainability of the production and operation phases. Finally, mimetic pressures are also found because the collected data shows that in some cases companies follow others simply because the innovation threshold is achieved. In other words, there is no point in trying to find something new or different if all the companies already tested that technology and are going in that direction.

Like referred earlier in the theoretical framework, with BIM also a social phenomenon (Cao et al., 2014) entailing a lot of communication and collaboration, it is also an institution with the ability to change others in a construction sector institutional environment.

Bröchner et al (2002) are stating that there is a connection between national Swedish culture and the institutional landscape in the sector. This cultural aspect was not a part of the inquiry of this research. However, given the findings concerning a stronger emphasis on the early design stages, the architect is given more responsibility and perhaps more influential power. However, according to Bröchner et al (2002), the low acceptance of elites of leading roles beyond the consultant context in the Swedish construction. Data has shown that some problems can emerge if the architect is under more pressure and responsibility but is not given a higher reward and recognition. In addition to that, the creation of new roles like the BIM coordinator must be considered in the context which the architect and the small architecture office must navigate through.

Finally, results are aligned with Succar (cited in Cao et. al, 2014), as the influence of BIM diffusion on an institutional level will become more significant on the level of SMEs in the ACE industry when the companies begin to evolve more toward BIM and the modelling stage into an integrated collaboration stage. From the selected companies, one company has shown to be stepping in to the integrated stage, using actively BIM both as Building Information Modelling and Building Information Management. This might serve as an indicator of the overall BIM diffusion in the selected companies, where most of them are in the BIM modelling stage or some of them haven't adopted BIM at all. Nevertheless, the collected data suggests that there is a general perception that the current situation will change and soon the demand for BIM will exist on a higher scale.

6 Concluding remarks and suggestions

6.1 BIM diffusion in small architecture offices

Literature has shown that many SME in this industry struggle or resist changing toward BIM. This study aimed at understanding how BIM diffusion is developing in small architecture offices in the Swedish market by inquiring to what extent is BIM implementation taking place and identifying what are the recurrent challenges and drivers. Moreover, a literature review was provided to support this study and an institutional theoretical lens was adopted to understand and identify the isomorphic processes taking place for BIM adoption. For this purpose, using a qualitative methodology, interviews were performed in five small architecture offices up to 20 employees and two software companies.

Regarding the *perception of BIM concept in small architecture offices*, this research is confirming what literature is already widely stating regarding different BIM definitions. Considering the selected BIM definition, this research has shown that BIM diffusion in the selected small architecture offices in Sweden is still in its early stages (Level 1). Each office is aware of that it is sooner or later becoming a requirement in this fast-developing industry.

Regarding the *challenges and drivers in BIM implementation in small architecture offices,* the client was identified as both the biggest challenge and driver. However, the companies where BIM implementation is taking place see the client more as a driver, while other companies, where BIM implementation is not yet taking place, see it more as a challenge. This is correlated with the current situation the company is facing according to age, clients and growth rate. Older companies tend to be more resistance towards BIM because their tools, methods and clients were consolidated over the years. On the other hand, companies which strive for growth are more open towards BIM, because the younger educated generation and clients are demanding it.

Findings suggest that significant isomorphic processes have been found in the selected companies when it comes to *external influences in BIM diffusion in small architecture offices.* Due to the nature and size of small architecture offices the presence of direct coercive and mimetic pressures when it comes to BIM diffusion is somehow limited. However, it was possible to identify in some cases that clients provide BIM requirements that can transmit coercive pressures in an indirect way. According to the selected data, there is a need for BIM perception and BIM requirements alignment in the market since BIM manuals can differ from company to company and municipally.

Normative isomorphic pressures have found to be insignificant when it comes to the Swedish architect association and this is aligned with the opinion of interviewed architects that think that the quality of architecture is considerably more important than a particular tool or methodology. On the other hand, normative pressures have been found to be significant when it comes to education and universities, especially in the small companies which are growing and hiring new employees. This creates a demand also for the employers to shape their organizations more into BIM adoption and creates an internal demand and competence for BIM that spreads through project team members.

6.2 Suggestions for further research

Further research into other actors that collaborate with small architecture offices would be beneficial to understand and compare results with this study. For that purpose, a study on the types of clients for small architecture offices in Sweden and what is their BIM perception and competence would provide necessary confirmation and cross referencing.
Another possibility for further research would be to perform a similar study to this one using a quantitative method on a wider sample. This would provide the possibility to see if results differ that much while changing the methodology and study sample.

Finally, an applied research approach would be beneficial from an internal architecture office perspective, considering the fields of organizational learning and BIM implementation. By applying different qualitative methods such as observations, ethnography studies and interviews with several employees in the same company it would be possible to better understand the learning processes and the challenges with different generations of architects and their perception of tools and technologies being used throughout the design stages.

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8 Table and figure index

9 Appendix

Appendix 1. – Interview guide for small architecture offices

I - The individual perspective

1. *Which term best describes your role in the firm?*
2. *How would you describe BIM?*
3. *How many years have you/the company been working with BIM?*
4. *What are you using BIM for? Which software do you use?*
5. *Do you intend in the future to develop projects using just BIM? (relate to answer n.2)*

II - The office perspective

6. *Please choose six out of the following challenges in implementing BIM in small architecture offices and rank them from 1 to 6 (being 1 the most relevant):*
    a. *Lack of time to learn the software*
    b. *Lack of competence*
    c. *Cost*
    d. *Resistance to change*
    e. *No demand from the client*
    f. *Our partners don't work with BIM*
    g. *Too complex*
    h. *Problems with internal coordination*
    i. *Time pressure to project delivery*
    j. *Other, please name and rank*

7. *Please choose six of the following drivers in implementing BIM in small architecture offices and rank them from 1 to 6 (being 1 the most relevant):*
    a. *We believe it brings competitive advantage*
    b. *Internal competence towards BIM*
    c. *Partners use BIM*
    d. *Easy to use and learn*
    e. *Demand from clients*
    f. *Internal demand*
    g. *Bigger projects*
    h. *Possibility to test model (clash detection, energy simulations, visualization)*
    i. *Avoidance of drawing errors with single model*
    j. *Time pressure to project delivery*
    k. *Other, please name and rank*

8. *How is the BIM implementation process working out in this firm?*
9. *What could be good to improve this implementation process?*
10. *If consulting services were available for transitioning to BIM, would you be interested?*

11 *Do you have any implementation activities like BIM workshops, software trainings etc.? Or does learning happens only in a more informal way?*

III - The institutional perspective

12 *What are the factors that can influence the decision to go to BIM implementation? Internal factors? How are the employees included in the decision process?*
   a) *Where do the factors come from? Clients, partners, public institutions?*
   b) *What role has the Sveriges Arkitekter? Did it influence you or this office?*
   c) *Are other office's decisions taken into consideration?*

13 *What do you think about the standard IFC format for project delivery in several public clients in Sweden?*

14 *Does the company places a high priority on maintaining up to date technology of both hardware and software?*

15 *What type of clients and projects are you aiming for?*

16 *Could BIM implementation change (or has changed) that project approach?*

17 *Do you have any further comments?*

Appendix 2. – Interview guide for software companies

I - The individual perspective

1. *Which term describes your role in the firm best?*
2. *How would you describe BIM?*
3. *What is your approach when selling the product to small businesses?*
4. *What are small to medium sized companies for you?*
5. *Do you see BIM as the future of the construction industry?*
6. *What would be the reasons for a company not to adopt BIM?*

II - The office perspective

7. *Please choose six out of the following challenges in implementing BIM in small architecture offices and rank them from 1 to 6 (being 1 the most relevant):*
   a) *Lack of time to learn the software*
   b) *Lack of competence*
   c) *Cost*
   d) *Resistance to change*
   e) *No demand from the client*
   f) *Our partners don't work with BIM*
   g) *Too complex*
   h) *Problems with internal coordination*
   i) *Other, please name and rank*

8. *Please choose six of the following drivers in implementing BIM in small architecture offices and rank them from 1 to 6 (being 1 the most relevant):*
    a) *We believe it brings competitive advantage*
    b) *Internal competence towards BIM*
    c) *Partners use BIM*
    d) *Easy to use and learn*
    e) *Demand from clients*
    f) *Internal demand*
    g) *Bigger projects*
    h) *Possibility to test model (clash detection, energy simulations, visualization)*
    i) *Avoidance of drawing errors with single model*
    j) *Time pressure to project delivery*
    k) *Other, please name and rank*

9. *How do you make your products attractive to small businesses that do not have the same financial resources as the larger companies?*
10. *Is there a minimum number of users from which BIM software would be recommendable? Can it also make sense for a two-man business?*
11. *Do you think BIM will become the new standard tool for AEC companies?*
12. *How do you carry out implementation activities like BIM workshops, software trainings etc.?*

III - The institutional perspective

13. *What can influence the decision to go to BIM implementation?*
14. *Where do the factors come from: clients, public institutions, competitors?*
15. *Internal factors: Individual, change in the project approach or other?*
16. *Which are the organizations that you think are making a difference towards BIM diffusion?*
17. *What do you think about the standard IFC format for project delivery in several public clients in Sweden?*
18. *How important is to maintain up to date technology of both hardware and software?*
19. *Should BIM implementation shift the business strategy in a company?*

20. *Do you have any further comments?*

Appendix 3. – Complete answers for questions n. º 6 and 7

In these questions the interviewees received two questions about BIM implementation in each of them they should rank the following challenges and drivers from 1 to 6 and give a short explanation, 1 is considered as the most relevant. According to the answers a table was created including all rankings side by side. We evaluated the rankings by saying that number 1 gets 6 points and number 2 gets 5 points and so on. This gave us the possibility to see which of the answers was the most important for the interviewees.

	En.#1	En.#2	Ar.#1	Ar.#2	Ar.#3	Ar.#4	So.#1	So.#2
1.	e.	i.	j.	i.	d.	e.	e.	c.
2.	i.	a.	e.	c.	e.	f.	f.	a.
3.	c.	e.	i.	b.	b.	i.	b.	b.
4.	f.	f.	b.	-	-	j.	d.	e.
5.	g.	h.	-	-	-	d.	g.	d.
6.	b.	b.	-	-	-	c.	a.	f.

(Table 1. Answers for challenges from each interviewee according to their rankings)

Ar. #1 - j. BIM model detail level/cost of project

Answers:

a. Lack of time to learn the software
b. Lack of competence
c. Cost
d. Resistance to change
e. No demand from the client
f. Our partners don't work with BIM
g. Too complex
h. Problems with internal coordination
i. Time pressure to project delivery
j. Other, please name and rank
\- *The other factors are not considered as relevant for the interviewee*

	En.#1	En.#2	Ar.#1	Ar.#2	Ar.#3	Ar.#4	So.#1	So.#2
1.	e.	a.	e.	a.	e.	b.	i.	e.
2.	h.	h.	a.	c.	g.	a.	h.	a.
3.	c.	i.	h.	d.	c.	e.	a.	h.
4.	g.	e.	i.	e.	-	g.	e.	g.
5.	-	c.	-	g.	-	j.	c.	i.
6.	-	j.	-	h.	-	h.	-	j.

(Table 2. Answers for drivers from each interviewee according to their rankings)

Ar. #2 - Was adding i. as the 7th point.

Answers:

a. *We believe it brings competitive advantage*
b. *Internal competence towards BIM*
c. *Partners use BIM*
d. *Easy to use and learn*
e. *Demand from clients*
f. *Internal demand*
g. *Bigger projects*
h. *Possibility to test model (clash detection, energy simulations, visualization)*
i. *Avoidance of drawing errors with single model*
j. *Time pressure to project delivery*
k. *Other, please name and rank*

- *The other factors are not considered relevant for the interviewee*