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# A Longitudinal Study of the Adoption of IT Technology in the Swedish Building Sector

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## ABSTRACT

The rapid development of IT technology has in the past three decades created opportunities for faster and more efficient processes as well as innovative new working methods in the building industry. This paper presents the results of a longitudinal survey-based study (the "IT barometer") of IT use in the Swedish building industry, conducted at several intervals over the period 1998-2011. The results show a rapid increase in general IT use as well as in the use of sector-specific tools. Improving communication and information sharing is a strong driving force for taking IT into use, for instance technologies such as EDM and EDI, although the adoption of the more complex applications (ie BIM) is slower. Interestingly "demands from employees" has over the years become a very important reason for companies to increase their IT use. Leading areas for planned IT investments include document handling and mobile equipment, with BIM technology rather low on the list.

## 1 INTRODUCTION

### 1.1. Background and purpose

In recent decades IT has provided completely new ways to communicate, consume media, and perform services via governments and banks, to name a few examples. It has also had a tremendous impact on how both industrial and service companies conduct their business. Also within the building sector, IT has helped to change the way we manage information, communicate, and to some extent change the processes and practices.

In light of this, there is a need for research regarding what types of IT tools are used in the industry, how they are used, what effects on productivity and quality they have as well as what perceptions industry stakeholders have of IT. This has been deemed interesting from several perspectives. Continuous measurement of IT use, effects and prospects gives the research community the opportunity to make analysis and draw conclusions about how different IT innovations contribute to increased productivity and efficiency in the sector, as well as areas in which further research is required. Also organisations funding R&D can benefit in the planning of new funding programs. The results of such research also provide

businesses with the opportunity to benchmark and make evaluations of completed and planned IT investments. The IT sector and software vendors can also use research results as support for decisions about how they should adapt their products and services to fit their needs of the industry.

In addition to the need for more empirical data on the IT-development in the sector we also recognised already from the start of the project the need to develop a rigorous method for conducting the study so that the results are representative for the industry and the average company. This was because many case studies and studies using convenience samples for instance using email lists of R&D programmes are reported in journal articles, conference papers and presentations, and often such results tend to give an overly optimistic view of the use of advanced technologies. Our hope from the start was that other researchers would copy and adapt the same method we have used.

This article describes the use over a period of more than one decade of the survey tool "The IT Barometer" [1], [2], [3], [4], a questionnaire that has been used, in whole or in selected parts, by in least 11 countries during the last decade [5] and thus allows for cross-country as well as longitudinal comparisons. This article aims in particular to describe the results of the fourth "IT barometer survey" in Sweden, which was performed in the spring of 2011, as well as to compare the results with the earlier studies. The quantitative study has also been supplemented with a qualitative interview-based study focusing on the adoption mechanisms of EDM, EDI and BIM technologies [6].

The purpose of each phase of the T Barometer survey has been to describe the current situation of IT use and its effects in the building sector, and through comparison with previous studies, analyse trends over time. The building sector is in this study is defined as contractors, architects, technical consultants, property owners and the material industry. This paper presents the results from a fourth measurement of IT use in the sector, and also provides a short review of similar studies conducted in other countries.

### 1.2. IT-barometers and similar surveys

The Project IT-barometer was initiated in the late 1990s and early 2000 as part of a national R&D program (IT BoF 2002) with the main purpose of measuring and following up the development of IT use in the Swedish construction sector. The purpose was also to create a method that could not only be repeated in Sweden, but also be used for international comparisons. An early collaboration between the Nordic countries resulted in surveys where the same questionnaires were used in Sweden, Finland and Denmark. Comparisons of the results are reported in [7], [2] and [8].

The method has since then been disseminated and used in other countries, with minor or major variations to the questions, depending on country variations and the different objectives and boundaries of each individual survey. These surveys are shortly described below, divided in three groups:

1. Surveys that extensively have used the IT barometer tool
2. Other studies with similarities to the IT barometer
3. Studies where the results of IT barometer surveys are used for analyses

*Surveys that have extensively used the IT barometer tool*

The first survey performed outside of the Nordic region was done in Canada [9], where large parts of the tool where used and where the author also contributed significant improvements to the survey design and the questions, which then has been used in future survey iterations. Other countries where IT-barometer surveys has been carried out, in its entirety or in

selected parts, are: New Zealand [10], [5], Singapore [11], [12], where a quantitative comparison with the Nordic countries was made; Nigeria [13], where an IT barometer study was performed also with the purpose to evaluate questionnaires as a method to also collect qualitative data; Indonesia [14] where a less extensive, modified barometer has been used, but with sufficient similarities to provide a basis for some comparisons; Malaysia [15]; Taiwan [16] and Turkey [17].

*Other studies with similarities to the IT barometer*

In Jordan a variant of the IT barometer has been used with a particular focus on the relationship between IT adoption and job satisfaction [18]. A survey in the south eastern United States used a similar survey methodology and developed the qualitative results of a regression analysis between IT use and firm performance [19]. Some studies have chosen to focus on a specific actor or certain tools. For example Chien [20] examines the use of I-Build technology i.e. IT tools for construction related business, and its impact on efficiency. Irlayici and Tas [21] focus on the strategic level of IT use by contractors. A special focus on BIM and its benefits and costs are presented in a study by Becerik-Gerber and Rice [22], and the use of IT in SMEs in building construction is described by Acar et al. [23].

*Studies where results of IT barometer surveys have been used for analyses*

Michaloski and Paula [24] analysed several barometer surveys and studied the technical, cultural and overall dimensions of IT. Ugwu and Kumaraswamy [25] used a similar survey as part of a method in a study of success factors for construction ICT projects, where it is combined with qualitative deductive analysis and case studies. Gaith, Khalim, and Ismail [26] performed an extensive literature review of a big number of studies with the purpose to clarify relationships between investments in IT and overall performance of companies in the construction industry. The review uses several of the performed IT barometers together with other surveys. Another literature review of ICT use in construction is made by Zietsman [27], which includes a classification of different research themes in the area, where 99 articles has been studied. Arif and Karam [28] present both a local survey with much similarity to the IT barometer, and an attempt to international comparisons between countries where barometer surveys has been performed. Conclusions were drawn for the areas General IT usage, Use of CAD and Use of Networks, among architects.

# 2 THE IT-BAROMETER SURVEY INSTRUMENT

To be able to measure the IT use in the industry over time a valid method had to be developed that could be repeatable and comparable over time. Much effort was therefore put into development of the method before the first survey was performed. This was done in 1997 and the method is thoroughly described in a master degree thesis [1], and also more briefly in [2]. The method is summarized in this section.

A number of choices have to be made, when performing a survey with satisfactory validity and reliability. The most important, which are described below, are: definition of *target population;* selection of *source for the population*; selection of categories to present, *stratification*; selection of data collection format, *type of survey*; and *weighting* of answers to correct for stratification.

*Target population and source for selection*

The target population was defined as all companies in Sweden working as architects, technical consultant (within the construction, civil engineering, and property management sector), contractors, property managers and also the construction material sector. There were a few possible registries that cover these categories of companies, and an evaluation of these resulted in a choice to use Statistics Sweden (SCB) [29] as source since they keeps a directory containing all companies in Sweden, categorized in a detailed way.

The SCB directory is updated every 3 months. It is possible to make the selection either on the basis of companies, or on the basis of workplaces, where workplace is defined as “each address, property or group of contiguous properties where the company carries out activity” [29]. The selection was made on the basis of workplaces for two main reasons. Firstly, many companies work with more than one type of business. Some workplaces can belong to multiple company categories and can thus use IT to a different extent and in different ways. Secondly, if a large company should be represented by only one questionnaire, this would cause some disproportion in the results, since it is weighted according to the number of employees. By choosing workplaces as a basis for selection, the possibility of getting a more detailed and true description of reality is increased.

*Stratification*

The statistical method chosen was stratified free random selection. “Stratified” means that the population is divided into a number of separate groups based on specific pre-defined characteristics. A free random selection is then used to make the selection of units within these groups. In this selection each unit in the population has the same probability to be part of the selection. This method using two steps is necessary if the survey is to be able to say something about parts of the industry. Otherwise it is only possible to make statements about the industry as a whole. It was decided that the study should be able to make statements partly about the industry as a whole, partly about categories of workplaces and partly about sizes of workplaces, but not the combination of the last two, which would have resulted in a need for a much larger sample selection. The selection was therefore stratified with respect to the following 9 strata (5 categories and 4 sizes of workplaces):

- Architects
- Engineers
- Contractors
- Property managers
- Manufacturers/Trade
- 1-9 employees
- 10-49 employees
- 50-199 employees
- 200+ employees

*Type of survey*

A request to answer the questionnaires was sent out by ordinary mail. The first two times, 1998 and 2000 the questionnaire itself where also sent out in paper format, while the last two times, 2007 and 2011, the request letter had instructions of how to complete the survey via a web form. The reason for sending by mail and not by e-mail was from the beginning of the study partly the risk of a major bias, since several questions concerned, for example, access to computers and email, which in this case would only be possible to answer if the respondent had such access. Partly, it was also a registry issue, since there was no available complete record of email addresses to all possible respondents. The approach with sending out letters was maintained even at the later surveys, partly for this reason, but the collection of data was made via a web form which facilitated both the respondents work and the work with the analysis of the received data.

*Weighting of the answers*

A stratified selection is customized to draw conclusions of each stratum, but not to draw conclusions of the sample as a whole, since the size of the selection of each stratum doesn’t correspond to its proportion in reality. To handle this, a weighting of the answers has to be done. Another item that has to be handled – if the purpose, as in this case, is to describe the total use of IT in a large number of companies – is the fact that large companies are few but represents a large number of employees, while there are a large number of companies with

few people employed. If each answer were given the same importance in the analysis, the result would be misleading. Because of this the answers also have been weighted with respect to the number of employees at each workplace, to make sure that each answer represents its part of the industry. The weighting is thus done in two steps, one for correction of the size of the sample according to its relation in reality, and one for correction of number of employees, to be able to draw conclusions of the total use in the sector, instead of the use of a certain share of companies. Table 1 describes the number of answers and response rate for each of the four surveys.

**Table 1 – Response rate IT barometers**

| | 2011 | 2007 | 2000 | 1998 |
|---|---|---|---|---|
| Selection size | 1507 | 1385 | 1316 | 2723[1] |
| Number of answers | 294 | 180 | 641 | 636 |
| **Response rate** | **20 %** | **13 %** | **49 %** | **23 %** |

# 3 RESULTS FROM 2011 SURVEY

## 3.1. IT infrastructure

The IT infrastructure in the form of access to computers and networks connections is good in the sector. No comparisons were made with other industries in this measurement, but previous studies [30] indicate that the building sector is at approximately the same levels as other sectors. The figures show a continued increase, in pace with developments in society in general.

The proportion of workplaces that have computers in 2011 was according to the survey over 99%. The few responses received via SMS from workplaces missing computers, can be attributed to very small establishments, which, after weighting with respect to size, implies an almost hundred per cent computerization. Similar results emerged from the 2007 survey. All workplaces that have computers today also have access to internet, which creates good opportunities for communication and information in the sector and in the projects. Increases have occurred during the whole measurement period, but already in 2007 the proportion was almost 100%.

Mobile connectivity has brought huge benefits to the sector, as even temporary workplaces such as construction sites may easily have broadband connections at their disposal. It also means flexibility for all participants in projects, which regardless of their geographic location can have access to shared information. In Sweden there is generally a high level of speed for Internet connections, with extensive fibre networks and a mature mobile infrastructure, where the third-generation mobile networks are capable of relatively high speeds. This is also corroborated by the respondents, where one out of four have access to 25 Mbps or more, and where almost 30% have capacities between 8 and 25 Mbps.

## 3.2. IT use with business focus

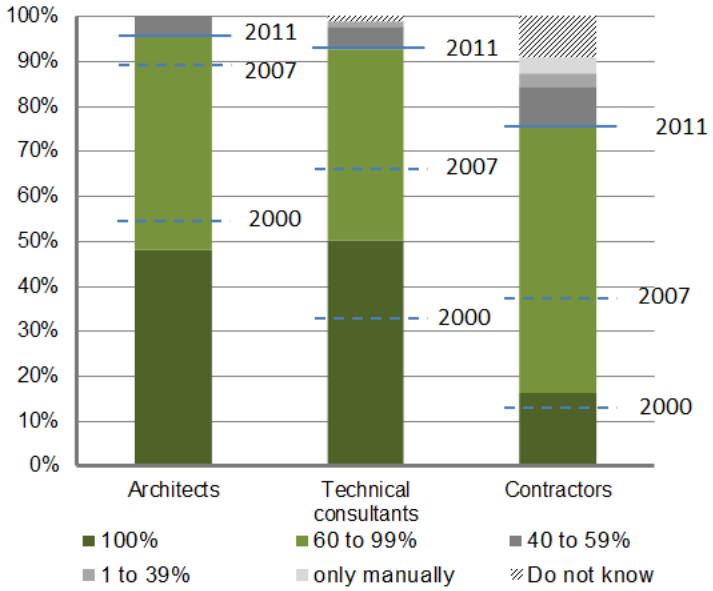
The sector has a high level of basic IT infrastructure, but how is IT used for supporting the core activities and the business? This question has been measured in the survey through a number of questions about the extent to which different operations are carried out with the help of computers; the extent to which information is exchanged digitally; and finally a number of questions about three areas given a special focus. These are Building Information Modeling (BIM), Electronic Document Management (EDM) and Electronic Data Interchange (EDI), which are described more under each heading. These areas have been chosen for their importance for information exchange and communication between different actors in the sector. They are interesting because they require cooperation between companies to be

[1] A larger selection was made to get results for combinations of strata

utilized optimally, while they may create benefits for both individual users and for the project process as a whole, as well as for the final product. BIM has been given more focus than other areas in this article since it is an area that has developed strongly in recent years and has been envisioned as potentially providing the strongest impact on both the sector's stakeholders and their processes, in the sense of increased efficiency and productivity

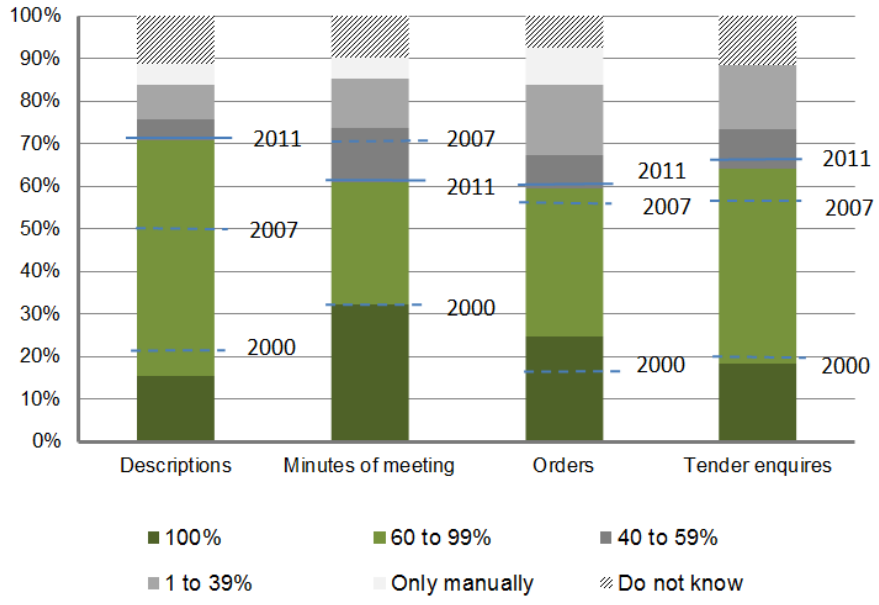
More and more information is created and stored digitally. The widespread infrastructure also enables a digital exchange of information. The two figures below (Fig 1 and 2) show how document-and file-based information is passed between players in the sector and how this exchange has changed during the measurement period. To compare the measurements between the years a point called the 60 percent point has been used, and this is marked for each year in the figures. It shows the level where all users use IT to 60% or more in work with the current operation.

Figure 1 shows the proportion of graphic documents, i.e. drawing based information, which is sent digitally. It is today done to a very high extent. Among those that most often create information, architects and technical consultants, about half of the respondents state that this is done to 100%, and almost all other are located at a rate above 60%, where also the range is wide (60-99%) and there are reasons to believe that many respondents are found in the upper end of the range. Contractors are slightly lower but still at a high level. In the figure, the 60-percent point is marked for the last three measurements and it shows that there have been marked increases, especially among contractors, where among other reasons mobile connections have made it possible to send and receive documents even at the construction site. The situation, which formerly could be described as a gap between the players, when the design and production stages managed information in different ways, have now been significantly reduced, which improves the communication in the projects.




**Figur 1 Proportion of graphical documents that are sent digitally.**

Figure 2 shows the result of how some common other types of documents are sent digitally. The level is fairly even between document types, where the 60% point for the different types are found somewhere between 60% and 70%, and where no major changes have occurred since the last survey. The rise in use took place mainly between 2000 and 2007. The common properties for these document types is that they are mostly text-based (except for bills), and that they are easy to create, send and receive thanks to de-facto standards such as MS office, pdf-writers and readers.




**Figur 2 Proportion of different types of documents that are sent digitally.**

Costing and budgeting are operations where there are well-established and refined applications in place, both in the form of simple spread sheets and through more advanced programs with recipe and price databases. The use is at a relatively high level, and is largely unchanged since the survey in 2007. The 60 per cent point is found between 50% and 60% for both contractors and consultants, but the proportion of those who use the programs to 100% is significantly lower among contractors. Also time and resource planning is an area where there is well-developed IT support at different levels. Simple project management tools such as graphical Gantt charts can be used and it is also possible to work with more sophisticated applications with for example links between activities and resources. Since planning is central in this highly project-based industry, there is potential and incentives for high usage. The results show slightly lower levels than for costing, especially among contractors (40%), but nevertheless it indicates a widespread use. However, it is surprising that contractors do not use more IT for planning and costing, which is operations that are of big importance for them.

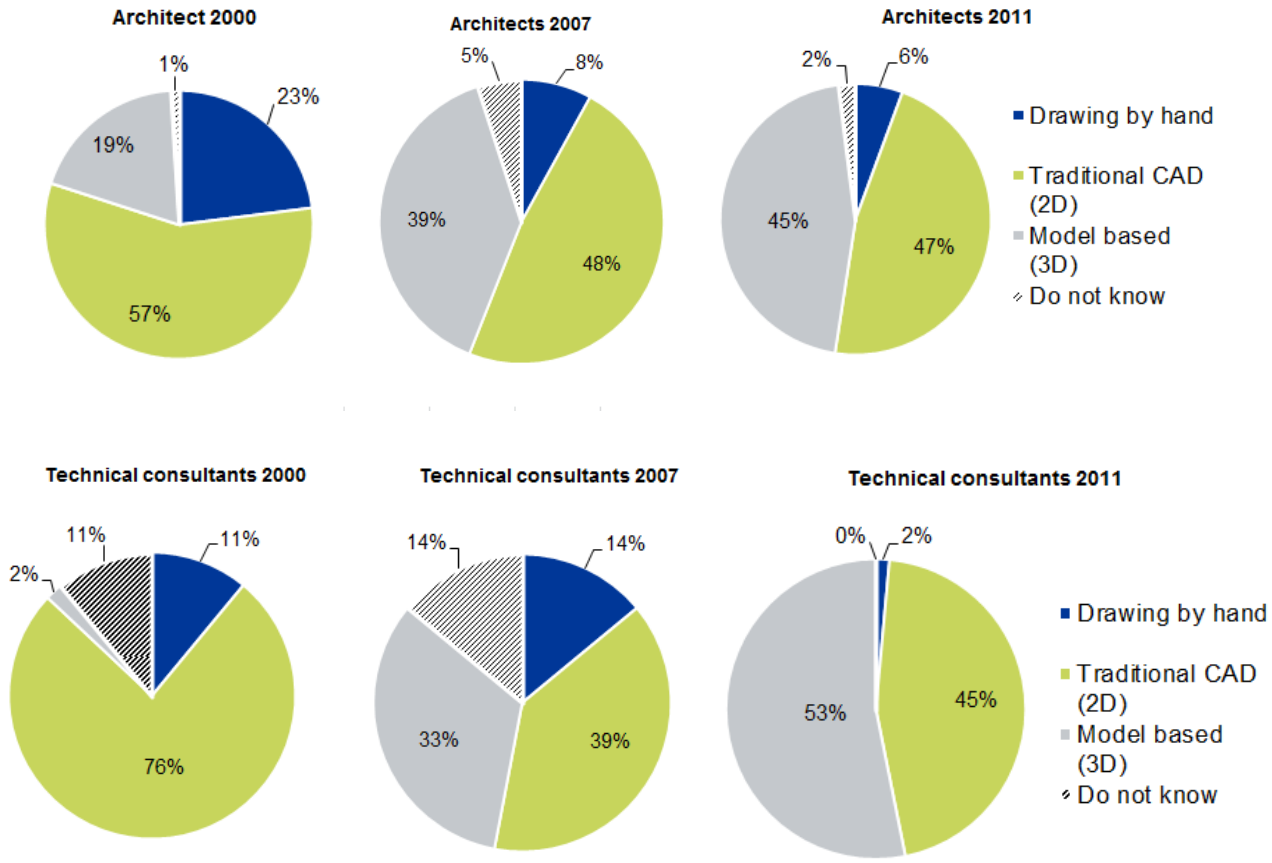
One area where contractors have increased their use of IT clearly is in materials management and purchasing, where the 60 per cent point has risen from 45% to 63%. In contractors business, purchasing and logistics are areas of big importance, where a wide variety of materials from different suppliers shall be handled, and where accurate delivery and price is absolutely critical for the benefit. IT systems that support this are therefore of great benefit.

## 3.3. CAD and BIM

The concept of BIM has been much discussed in the sector and has been given a number of different definitions. Eastman et al. [31] describes BIM as: models containing *all* the information about the *product* and the *process* through a building's *lifecycle*. In brief, BIM is about modelling the physical building objects as well as spaces in a computer, providing the objects with geometrical and other properties, as well as the relationships between the objects created. The models can then be used to manage all possible information about both the product and the process. The acronym BIM can represent both the digital models built (Building Information Model), and the work required (Building Information Modeling) to achieve the effects of the improved information management.

In order to work with BIM it is therefore required that the basic information created by designers, is created model-based instead of with traditional 2D CAD. Figure 3 shows that designers currently use tools that support model-based information almost half of the time

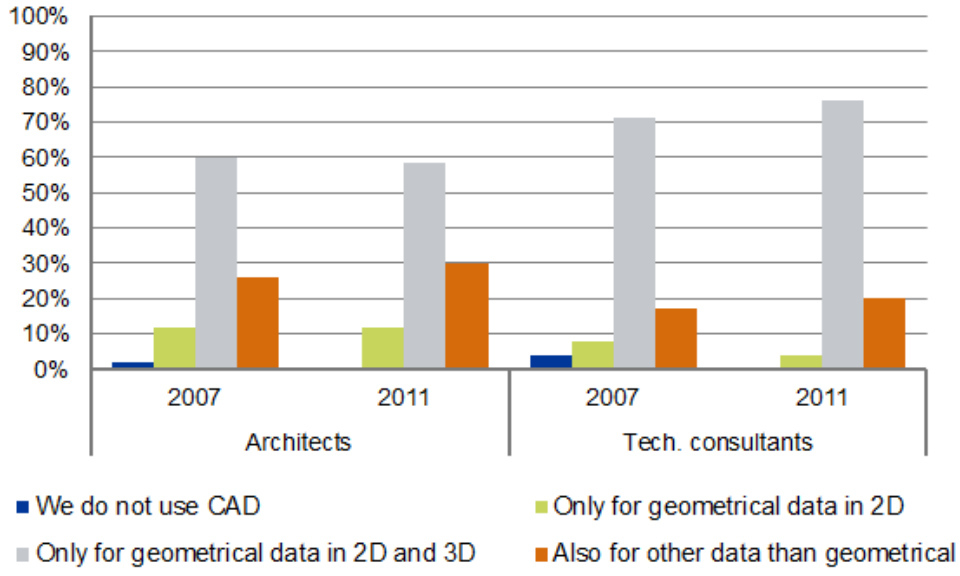
they spend on design. There has been a marked increase in a decade, especially during the second half of the period. Hand drawing as a tool has decreased continuously. Even "sketching" of areas and volumes in the early stages is now often done using computers.



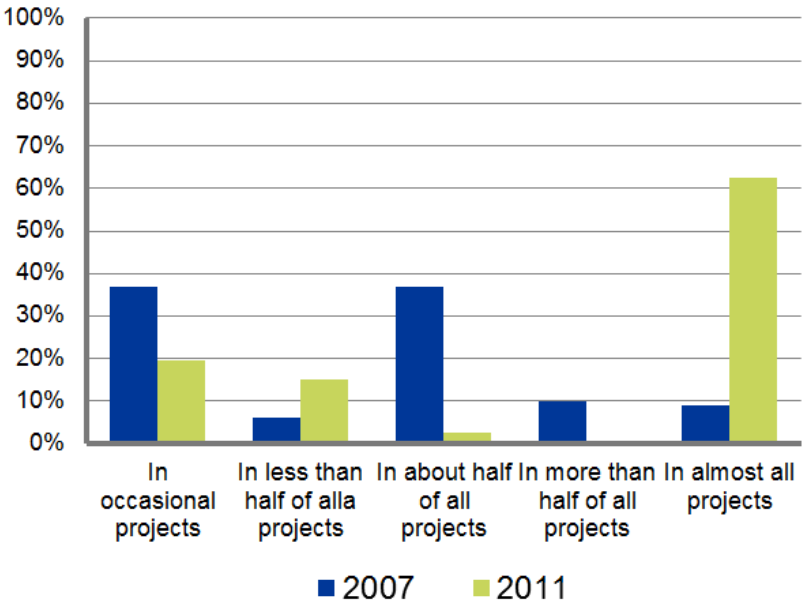

**Figur 3 Proportion of total design time where different tools are used.**

The fact that model-based tools are used does not automatically mean that all their functionality is used. Figure 4 shows to which level the tools are used among architects and technical consultants. The clearly highest bars refer to "Only for geometric data in 2D and 3D." This indicates two things. Firstly, that the proportion of designers that only work in 2D is low and continues to fall, and thus that the use of CAD in both 2D and 3D now is the normal manner to work for designers. Secondly it means that information about geometry still is the most important and that most designers have not yet taken the step to start using models to other kinds of data than geometric. The proportion of those who work "Object based also with other data than geometric" is higher among architects than technical consultants, but has risen in both.

Figure 5 shows the frequency of use of those who answered "also for other data than geometrical" to the question in Figure 4. The base for the sample is very small and conclusions based on this should be made with caution. The figure indicates however a high frequency of use by the minority that uses the models in an advanced way.




**Figur 4 Proportion of use of CAD for different types of data.**



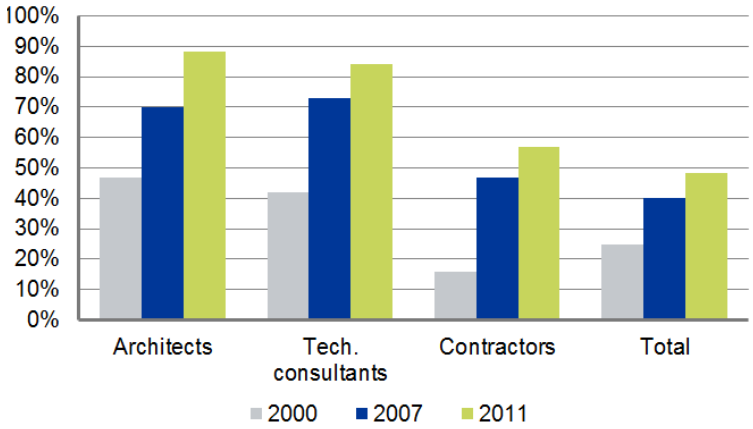

**Figur 5 Distribution of CAD use frequency for non-geometrical data.**

The above reasoning also confirms the general picture of BIM development in the sector that is presented in industry seminars and trade press articles. To meet the traditional requirements of delivery, it is often at present more efficient to operate traditionally. There is, however, a clear trend that information about buildings and their processes are mediated more in model form and that the models are starting to be used for other information than geometry. There is a broad consensus about BIM as an effective tool and work method. In practice, the development is today driven by a number of BIM experts, and these can be found in more and more companies. However, they are a limited group of individuals, but they are working intensively with the development.

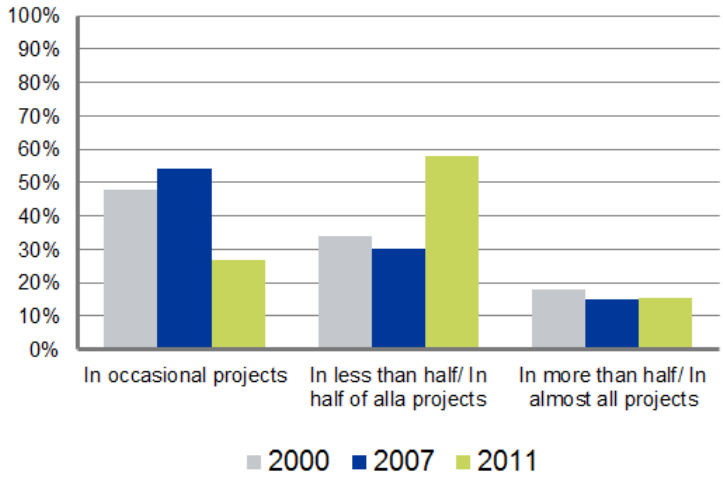
## 3.4. EDM and EDI

Although model-based techniques for information management are gaining ground, the bulk of all information is still shared through documents. The number of documents and versions of them have rather increased owing to the ease of creating and distributing them. A systematic way to store and organize documents, then becomes necessary for searching and accessing documents, and to manage the huge flow of information that a project member is expected to handle. The following two graphs (Figure 6 and Figure 7) show the distribution and frequency of project-based electronic document management (EDM), i.e. web portals where different suppliers are providing the services through the Internet. The questions are not related to electronic document management within the company but the kind that is shared by multiple actors in a project. The proportion of workplaces that use EDM is 50% in the sector as a whole, where the architects are taken the lead with nearly 90% usage. Contractors use is clearly lower, but all categories have increased their use over the measurement period, and the increase can be stated as a very clear trend.

In addition to an increasing number of companies using EDM systems, the frequency of use within companies is also increasing. Figure 7 shows that those who state that the system is used "in almost all projects" is low and unchanged, but that a movement has occurred from the category "in isolated projects" to the category "half of all projects." The systems are not effective for all types of projects, but require a certain size for the benefits to outweigh the effort. The increased frequency of use shows, however, that experienced users achieve benefits in more and more projects.




**Figur 6 Proportion of employees at workplaces where EDM is used in projects.**

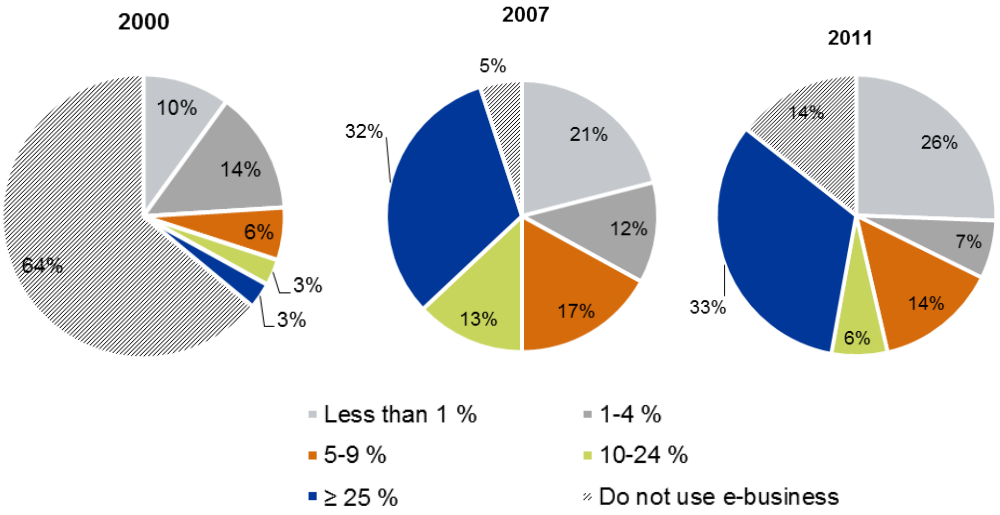



**Figur 7 Proportion of how often EDM is used in projects.**

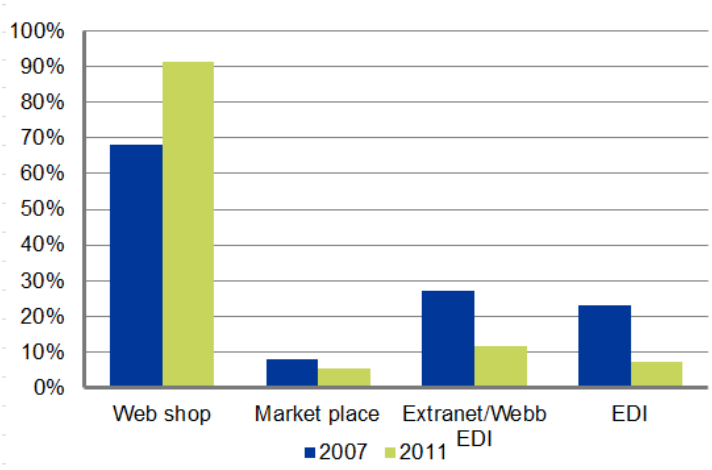
E-commerce is another area in IT development that involves information exchange *between* actors in the sector. Today a third of the sector performs more than 25% of their purchases electronically in any manner (fig. 8.) The proportion increased significantly between 2000 and 2007, but remained largely unchanged between 2007 and 2011.

The way to work with e-commerce has been divided into four levels. Web shops are the simplest and mean that a selling company puts up a website with its assortment, its pricing and ordering options, and that the buyer manually places their orders via the portal. Payments can be made in different ways. The most advanced form of e-commerce is "Full EDI" where a seller and a buyer have connected their business systems and exchange business information via standardized electronic messages, from catalogues and price lists by orders through invoicing and payment. EDI requires initial resources to set up systems and standards, and are therefore often based on long-term contracts between sellers and buyers.

Figure 9 shows that it is the simplest form of e-commerce, i.e. web shops, that accounts for 90% of the use, and that this category also is increasing. The more advanced forms, with greater initial effort for both buyers and sellers, decreases in favour of the benefit of trading via online shops, despite the fact that the potential for efficiency is considerably higher within the more advanced systems. The simpler solutions are more accessible, provide faster efficient gains and make the everyday work easier. They are also available to smaller businesses and do not require investments to the same extent.




**Figur 8 Proportion of purchases done with E-commerce.**

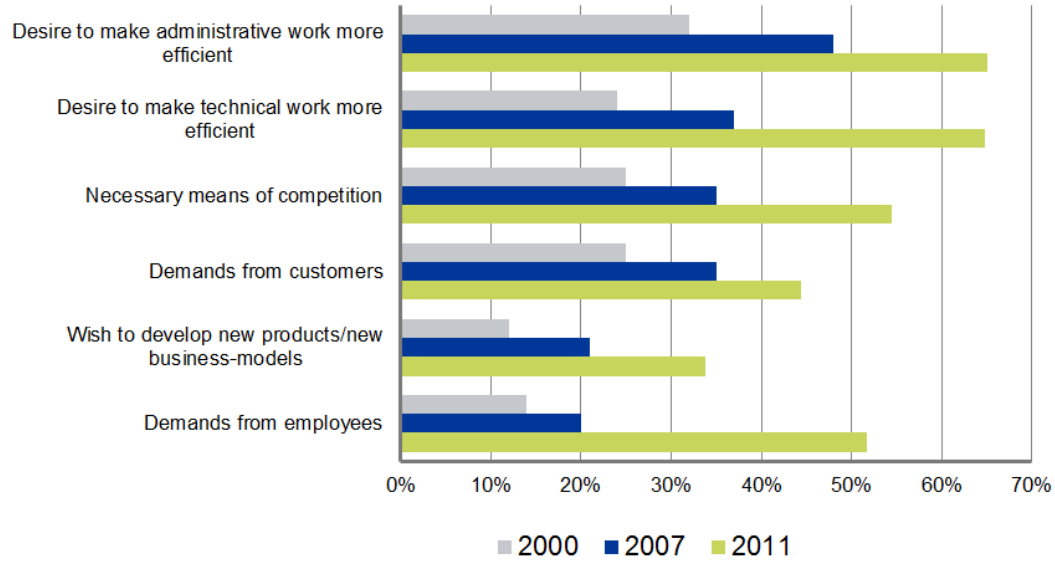



**Figur 9 E-commerce usage proportions.**

## 3.5. Effects and strategies

Figure 10 shows the importance of different motives for an increased use of IT within the companies. The figure shows the percentage of respondents answering one of the two top options ("important" and "very important") on a five-point scale concerning how important different motives are for an increased IT use. The answers should largely be considered relative to each other since it is easy to consider all items important, in answering these types of questions.

According to the answers, the most important motives are to make the "technical" and "administrative" work more efficient. These two motives have been considered most important at all measurement occasions. Both motives get the same high value. Least important is the development of new products/business models. Also this is the same result as in previous measurements. It indicates that there is a clear ambition to improve the old work methods, i.e. doing "the same thing but faster." Few of the respondents tend to strive to use IT to develop their business and perform things in new ways. The biggest change in the relative order is the motive "Demands from employees", which is considered more important at the latest survey. New generations who entered the labour market have grown up with new technology and modern internet-based communication. They have completely different requirements and expectations of these tools. Even if one must be cautious in comparing the absolute numbers, it is a clear trend that all motives increasingly become more important, as well in the 2007 as in the 2011 survey. This may indicate that IT is generally a more important parameter, and is in some cases regarded as self-evident.

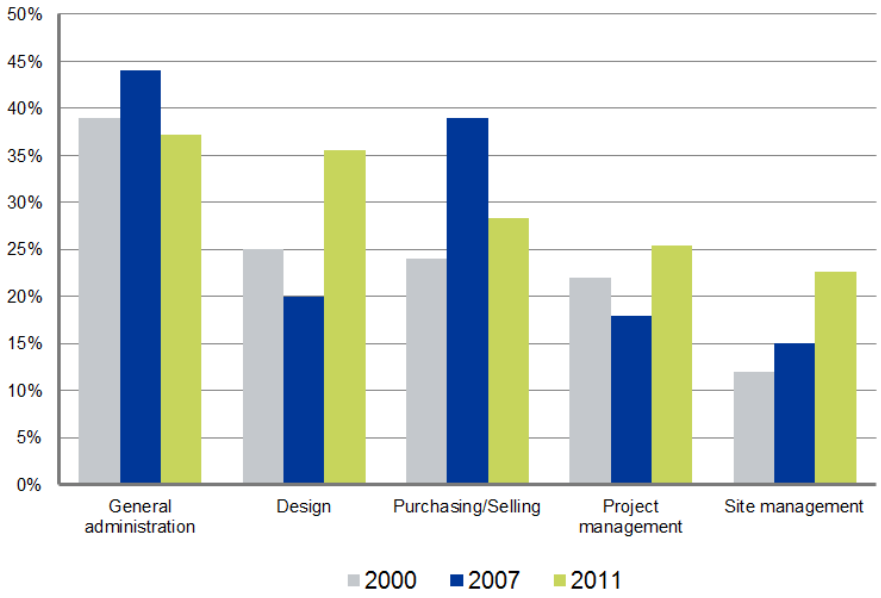



**Figur 10 Importance of different motives for IT investments**

Figure 11 states the proportion of those who have experienced productivity gains (with more than 15%) in five different areas. The areas are arranged by decreasing rate for the 2011 survey. Most respondents experience higher productivity in "general administration". Figure 10 above also shows that efficiency of administration is an important motive. Administration has been highest at all three measurements occasions according to the figure.

An almost equally high percentage thinks that productivity has increased in design. There is a clear increase when comparing with the two previous surveys. Design was number two in the survey 2000 and then declined in the 2007 survey. In 2011 it was again one of the two areas where increase of productivity has occurred to the highest extent. At the survey 2000, CAD had taken over drawing by hand and was widely implemented among the design companies. At the time for the 2011 survey object-based design had started to gain ground among the designers, which can explain the experience of new productivity increases.

Purchases/sales have fallen, which may be related to a lower use of advanced e-commerce such as EDI as stated in section 3.4. Workplace management has been the last at all the three measurement occasions, but has continuously increased in absolute terms. Even on the construction sites thus, more and more benefits occurs by using IT-based tools.




**Figur 11 Proportion of employees in workplaces that experience increase in productivity with more than 15 %, caused by IT, in different areas.**

Table 2 to Table 4 below describes the advantages, disadvantages/obstacles and planned areas for investment in the coming years. For each question, respondents had to select up to three areas. The percentage in the table describes the proportion of respondents that consider the area to be one of the three most important. The tables are sorted in descending order of priority, with the previous year's position in each column. The main trends are marked with arrows.

Regarding perceived benefits in Table 2 "possibility of sharing information" tops the list. This is an area that has slowly increased since the first survey. Number two is "Simpler/faster access to common information", which is closely related. The ability to share and communicate information is clearly a strong advantage in this project-based sector and has been highly prioritized in all measurements. "Work done more quickly" was high on the list in 1998 and has now regained a place among the first three.

"Better financial control" has fallen back after top rankings in the 2000s. The concept concerns both corporate and project accounting, and there has probably been a lot of development in the last 10 years, but the curve is flattening. The changes have already taken place, and the IT tools are today regarded as a matter of course.

**Table 2 Perceived benefits of increased IT use**

| TOTAL | (%) | 2011 | 2007 | 2000 | 1998 | Trend |
|---|---|---|---|---|---|---|
| Possibility of sharing information | 40 % | 1 | 3 | 4 | 6 | ↗ |
| Simpler/faster access to common information | 29 % | 2 | 1 | 2 | 1 | |
| Work done more quickly | 28 % | 3 | 4 | 6 | 3 | ↗ |
| Better quality work | 24 % | 4 | 6 | 7 | 2 | |
| Better communications | 20 % | 5 | 7 | 3 | 4 | |
| Easier to handle large amounts of data | 19 % | 6 | 8 | 5 | 7 | |
| Possibility of teleworking/telecommuting | 18 % | 7 | 4 | 9 | 9 | ↘ |
| Greater flexibility for satisfying customers | 14 % | 8 | 9 | 8 | 8 | |
| Better financial control | 13 % | 9 | 2 | 1 | 5 | ↘ |
| Possibility of developing new products/new business models | 8 % | 10 | 12 | 11 | N/A | |
| Makes the company more attractive when recruiting staff | 3 % | 11 | 10 | 10 | 10 | |
| Possibility of reducing staff | 0 % | 12 | 11 | 12 | 11 | |

A very clear and stable top ranking among obstacles in Table 3 is the area "Continuous demand for upgrading hardware and software." The technical development requires continuous changes in systems. It is not possible to forgo upgrades, partly because of cooperation reasons when some systems become de-facto standards, and companies depend on that same versions as other companies are using, partly for reasons regarding licensing models. Software purchased almost always include so called subscription agreements which involves yearly payments for future versions. The actual investment costs are also a barrier, but probably experienced "fairer". It is always possible to refrain from an investment after a completed cost–benefit analysis, but that choice is not the same for the upgrade of software.

The area “non-compatible software” as an obstacle has increased in importance and is reported by nearly 30% as one of the three biggest obstacles. Since the greatest benefit is stated as “sharing common information”, systems must be flexible and able to talk to each other. The on-going work in the sector around BIM, where information has to be able to be exchanged between different types of software, also makes this an important area.

**Table 3 Perceived disadvantages/obstacles of increased IT use**

| TOTAL | (%) | 2011 | 2007 | 2000 | 1998 | Trend |
|---|---|---|---|---|---|---|
| Continuous demand for upgrading hardware and software | 42 % | 1 | 1 | 1 | 2 | |
| Investment costs too high | 32 % | 2 | 5 | 2 | 1 | ↗ |
| Non-compatible software | 28 % | 3 | 7 | 6 | N/A | ↗ |
| Greater know-how required from staff | 25 % | 4 | 4 | 3 | 3 | |
| Overabundance of information | 24 % | 5 | 2 | 4 | 7 | |
| Risk that IT leads to inefficiency | 16 % | 6 | 6 | 9 | 12 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| General attitude that old ways of doing things have worked well throughout the years and changes are unnecessary | 14 % | 7 | 3 | 5 | 5 | ↘ |
| Reduced security | 11 % | 8 | 12 | 8 | 13 | |
| Difficulty in measuring profit/assessing investments | 7 % | 9 | 10 | 10 | 4 | |
| Decision-makers have no time for IT efforts because of heavy workload | 6 % | 10 | 9 | 7 | 6 | |
| Preference for manual working because of lack of standards/coordination | 5 % | 11 | 11 | 11 | 8 | |
| Insufficient management interest/commitment | 3 % | 12 | 7 | 12 | 9 | |

Among planned investments in Table 4 "Document management" still tops the list. Most of the information that is created and shared is stored in the format of documents, and the handling of documents has topped the list of priorities at each measurement occasion. This can be interpreted in different ways. On one hand, that it is an on-going and important issue that must be constantly developed. On the other hand, it is noteworthy that the problems in this area seem not yet to be solved. The fact that the area constantly is the most important can be a signal that there are problems that are difficult to manage.

CAD investments are again among the top three areas. Also BIM has risen in priority among planed efforts, but only 11% of the sector as a whole considers it one of the three most important areas. However, the fact that CAD issues get high priority among the whole sector, suggest a willingness to use CAD information in new ways, even if not everyone refers to it as BIM. The figures describe the responses for the sector as a whole. A more nuanced view is given if studying the individual business categories separately, where for example BIM is given the highest priority of all among Architects. 66% of the architects consider BIM as one of the three most prioritized areas.

The fact that information retrieval on the Internet gets a high priority among future investments may at first seem surprising. However, the Internet today is quite different than it was ten years ago. The way to communicate through so-called social media, the amount of structured factual information through wikis and forums on every conceivable subject areas, the provision of so-called cloud services instead of purchased software, indicates probably that the companies are working in new ways with these issues and that the potential of the Internet leads to new efforts.

**Table 4 Areas for planned IT investments, in order of priority**

| TOTALT | (%) | 2011 | 2007 | 2000 | 1998 | Trend |
|---|---|---|---|---|---|---|
| Document handling | 35 % | 1 | 2 | 1 | 1 | |
| Portable equipment/mobile systems | 25 % | 2 | 1 | 4 | 8 | |
| CAD | 25 % | 2 | 6 | 7 | 4 | ↗ |
| Information search via the Internet | 23 % | 4 | 7 | 8 | 2 | ↗ |
| Accounting systems | 21 % | 5 | 3 | 3 | 3 | ↘ |
| Project management | 18 % | 6 | 8 | 5 | 6 | |
| Systems for technical calculations | 16 % | 7 | 12 | 11 | 9 | |
| Project webs (EDM) | 12 % | 8 | 9 | 10 | N/A | |
| Product models/BIM | 11 % | 9 | 13 | 14 | 11 | ↗ |
| Systems for costing/cost control | 10 % | 10 | 5 | 2 | 5 | ↘ |

| | | | | | | |
|---|---|---|---|---|---|---|
| E-commerce | 6 % | 11 | 4 | 6 | 7 | ↘ |
| New business models and activities | 2 % | 12 | 10 | 13 | N/A | |
| Virtual Reality | 2 % | 12 | 13 | 15 | 10 | |
| Systems for real estate information | 1 % | 14 | 11 | 12 | N/A | |

# 4 DISCUSSION AND CONCLUSIONS

The IT development in the building sector is moving forward. It does not always occur in the way or at the speed that is expected, but there are continuous changes. Previous studies have shown that the general use of ICT in the sector, such as computers per employee, network capacity, access to mobile phones, applications such as word processing, spread sheet, email, intranet, etc., are used in approximately to the same extent as within other sectors.

However, how IT is used in the companies' core businesses, i.e. sector specific activities and operations, is interesting. The description of the general IT use above is about following the trends, while IT in the core business is about driving development and innovation towards higher profitability, business value and productivity. It is in these areas, that the sector is able to increase profitability and productivity more than only at the margin. It requires, however, often making major changes and daring to question old methods and ways of working. To take full advantage of IT, new ways of working is essential.

The results of the survey show that the sector is gradually increasing the use of IT to support various operations, such as planning, logistics, design, and purchasing. This is not done with large well defined change efforts, but with small steps, where individuals often have great freedom to choose their working method and tool. The biggest changes are not seen in the performance of individual operations, but instead in the communication and dissemination of information. Digital document exchange, electronic document management systems and building information models as carriers of shared information, are areas which are expanding and increasing in use. The ability to make common information available is also a clearly perceived benefit of IT in the sector. Communication is a strong driving force in this information-intensive industry sector, which involves a number of stakeholders that have to collaborate in projects, and where these stakeholders are combined in new ways in each new project. However, the number of stakeholders results in problems regarding the development. If new ways of communication and information dissemination are being introduced, and the development occurs more quickly with certain stakeholders than with others, there might ensue communication problems. The study shows that contractors are less likely to use EDM and BIM, and generally have a lower IT maturity, resulting in an uncertainty if they can use all the information supplied.

However, this seemingly slow development has practical and commercial explanations, which also are connected to the complex relationships in the sector. Companies and individuals act rationally in most cases. A change in an activity or an effort of any kind should be worthwhile, either directly for the person doing it, or to a nearby function. An effort that provides a direct simplification or other significant rewards is performed immediately, while an effort with an uncertain outcome, or even the lack of effect on the person doing it, will not happen.

Several of the areas outlined in the study have a clear impact on the project level: better structure and availability of information via EDM, coordination and integration of shared information through BIM, or fast and efficient procurement processes via EDI. Benefits occur at a higher level or in the longer term, and these systems require different types of initial efforts that can sometimes be difficult to justify. BIM does not necessarily provide increased profitability for a designer who will deliver drawings. To enter metadata and upload a

document into a portal for the convenience of someone else is not always time efficient for the individual. The way that construction projects usually are procured seldom give room for innovation, but instead favour established approaches. However, if a company can sharpen its processes and improve its internal operations, and as a result deliver higher quality at lower cost, it gets a competitive advantage. It is also shown in the study that streamlining existing processes is a bigger driving force for the companies than to experiment with new ways of working. The latter is much more difficult for companies to influence since they are only one piece in a larger context of companies and processes in this project based sector.

With this as a background, it is interesting to note the developments in more complex technologies such as BIM. It is not just short-term profit motives that drive investments, but also a curiosity and a desire to do things in better and new ways, not only in a company's own operations but in the construction process as a whole.

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