

# A framework for selecting an IT evaluation method - in the context of construction

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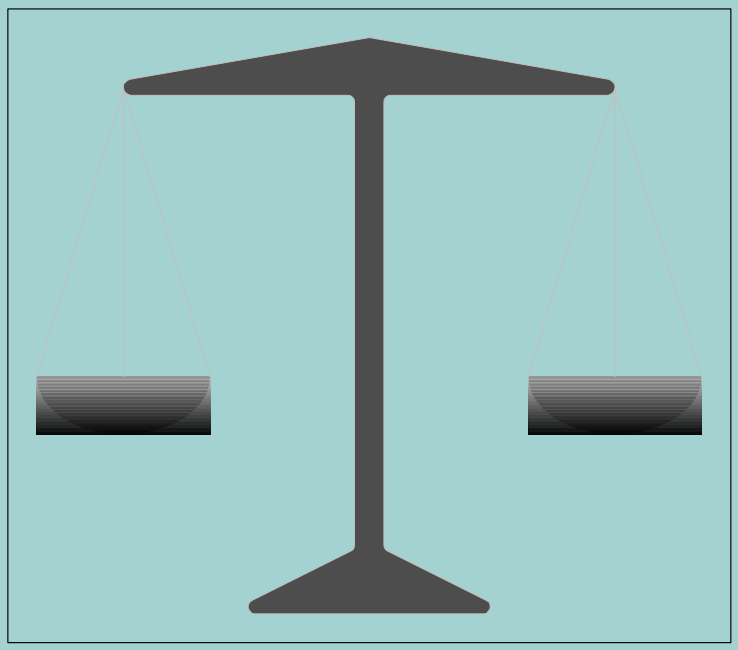
- in the Context of Construction



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# Preface

Throughout the time spent at the Technical University of Denmark my interests have been related to three topics: construction, management and IT. Finishing this Ph.D. project has given me the opportunity to work in greater detail with each of these, and this has indeed been a worthwhile experience, but has also (maybe more importantly) taught me how much I still have to learn.

The usage of IT in construction is much debated among researchers and practitioners and this thesis will hopefully contribute to this debate. The central result in the present thesis is a framework for how companies from the construction industry can choose from the available IT evaluation methods. The framework is developed using a scientific approach on the basis of theoretical and empirical work. It consists of a number of parameters, which are useful to describe different IT evaluation scenarios, as experienced by the companies from the construction industry. Each IT evaluation scenario is compared with a number of IT evaluation methods and, through this, the best match can be identified.

The thesis is based on three years of work at the Technical University of Denmark at BYG.DTU, in the Construction Management group. During this period my supervisor, professor Rob Howard, has given much support and useful advice and comment, which have been valuable for my work. A number of conference papers and a journal paper have been presented and/or published (see the list in Appendix J) giving me an opportunity to share my work with others. A 6 months stay at the School of Construction, and Property Management, at the University of Salford, Manchester has given me an opportunity to meet other researchers with similar interests. In particular professor Martin Betts encouraged and inspired me in the further progress of my Ph.D. project. Furthermore I want to thank my colleagues at Construction Management for their support and helpfulness, especially assistant professor Susanne Hartvig, associate professor Per Galle and research assistant Ernst Petersen.

An important part of the empirical work would not have been possible without the collaboration of five companies from the Danish construction industry. I would like to thank the persons involved in the case studies in the companies: Rambøll, Cowi, NIRAS, Højgaard & Schultz and Troels Jørgensen A/S.

Lastly, thanks to my girl friend Lone, who supported and cheered me up in times when I needed it and because of the great patience she has shown during the long time I have spent on this Ph.D. project.

Jan L. Andresen
September 2001, Lyngby

# Abstract

The purpose of the research, 'A framework for selecting an IT evaluation method', is to improve the benefits from the use of Information Technology in companies from the construction industry, by helping them to identify the value of IT to their organization. The Productivity Paradox states that it has not yet been proved that the productivity of whole industries has been increased as a result of investment in IT. In the Danish construction industry productivity has not increased in the last 30 years, although there are many influences on this of which IT is only one.

The research asks the question: 'How should a company in the Danish construction industry choose an evaluation method to be used when evaluating each IT investment?' Following a literature search which found 82 different evaluation methods, and a survey of Danish companies which found little use of formal evaluation methods, the following hypotheses were posed:

- There is not one best evaluation method for all cases
- The use of the framework for the identification of the best matching IT evaluation method for an IT investment improves a company's evaluation practice.

Evaluation of the costs and benefits of acquiring or developing, and managing the introduction of, computer systems in a company, is needed to establish if and when there would be a business advantage. This evaluation should be repeated after a system is in place to see whether the expected advantages were achieved.

After considering whether to develop a better method of evaluation, specifically for the construction industry, the student decided that a framework for choosing the right type of method would be more useful. Case studies showed that different companies and different types of IT investment, required different methods, and the factors that influenced decisions were used to build the framework, which is the main output of the thesis.

The framework takes into account the nature of the company, its use of IT, business objectives and reasons for evaluation. It weights these according to their importance, and matches a company's needs to one of four generic types of method. These are the best known or documented methods, although there are many others of each type. A knowledge-based computer tool has been developed to show how the framework could be made simpler to use, and this has been shown to, and commented on, by some of the case study companies.

The thesis ends by proving the hypotheses through the validity of a number of sub-statements. It provides useful guidance, not just for the case study companies who found the help given by the student in trying out several methods useful, but also for the Danish construction industry in general. This spends up to 5% of its turnover on IT systems and has made little use of formal evaluation methods so far. The software tool for using the framework could be developed into a complete package, making IT evaluation easier and thereby helping to increase productivity.

# Resumé

Formålet med afhandlingen, 'Et rammeværktøj til udvælgelse af en IT evaluaeringsmetode', er at forbedre fordelene ved brugen af Information Teknologi i virksomheder fra byggeindustrien, ved at hjælpe dem med at identificere værdien af IT i deres organisation. Produktivitet paradokset fastslår at det endnu ikke er bevist at produktiviteten af hele industrier er øget som et resultat af IT investeringer. Den danske byggeindustris produktivitet er ikke steget gennem de sidste 30 år hvilket skyldes mange årsager, hvoraf IT kun er en af dem.

Afhandlingen stiller spørgsmålet: 'Hvordan skal en virksomhed fra den danske byggeindustri vælge en evalueringsmetode når en IT investering skal evalueres?' Udfra et litteraturstudium, der fandt 82 forskellige evalueringsmetoder, og en spørgeskemaundersøgelse, som fandt en lille anvendelse af formelle evalueringsmetoder, er følgende hypoteser opstillet:

- Der er ikke en bedste evalueringsmetode for alle tilfælde
- Anvendelsen af rammeværktøjet til identificering af den bedst matchende evalueringsmetode til en IT investering forbedrer en virksomheds IT evalueringspraksis.

Evaluering af omkostninger og fordele ved anskaffelse eller udvikling, og ledelse af introduktion af, computer systemer i en virksomhed, er nødvendig at etablere hvis og når det er en forretningsmæssigt en fordel. Denne evaluering bør gentages efter at et IT system er implementeret for at identificere hvorvidt de forventede fordele er opnået.

Efter en overvejelse om hvorvidt en bedre metode til evaluering, tilpasset byggeindustrien, skulle udvikles, besluttede den studerende at et rammeværktøj til udvælgelse af den rigtige type af metode ville være mere brugbart. Casestudier viste, at forskellige virksomheder og forskellige typer af IT investeringer, krævede forskellige metoder, og de forskellige faktorer med indflydelse på deres valg er anvendt til udviklingen af rammeværktøjet, hvilket er det centrale udbytte af afhandlingen.

Rammeværktøjet tager hensyn til virksomhedens karakteristika, dens brug af IT, forretningsformål og grunde til evalueringen. Den vægter disse i overensstemmelse med deres vigtighed, og matcher en virksomheds behov til en af de fire arketyper af metoder. Disse er de bedst kendte eller dokumenterede metoder, selvom der er mange andre af hver type. Et vidensbaseret computerværktøj er blevet udviklet for at vise hvordan rammeværktøjet kan gøres nemmere at bruge, og dette er blevet demonstreret til og kommenteret af nogle af case studie virksomhederne.

Afhandlingen slutter med at bevise hypoteserne gennem en validering af en række udsagn. Den giver en brugbar vejledning, ikke alene for casestudievirksomhederne som fandt hjælpen fra den studerende i afprøvningen af forskellige metoder brugbar, men også generelt for den danske byggeindustri. Denne investerer op til 5% af dets omsætning på IT og har i lille grad anvendt formelle evalueringsmetoder indtil nu. Softwareversionen af rammeværktøjet kan blive videreudviklet til en komplet pakke, der gør IT evalueringen nemmere og derved hjælper med at øge produktiviteten.

# Contents

# Chapter 1: Introduction

During the last few decades the development of information technology (IT) has been at an incredible speed when many companies are struggling just to keep pace with development. Many companies from the construction industry are therefore spending an increasing amount of money on IT, but are they really getting value for money for these investments?
3
Researchers have, for some time, been debating whether there is an *IT productivity paradox*[1] or not. (Strassmann 1990) found, for example, that there was little correlation between a company's investment in IT and its productivity, which led to the conclusion that IT spending has been unproductive. A few years later (Brynjolfsson 1993) reviewed the overall literature on the IT productivity paradox and concludes "shortfall of evidence is not necessarily evidence of a shortfall". In 1998 findings were published that concluded the paradox was lost[2] and it was even suggested that it never existed, (Brynjolfsson & Hitt 1999). Within a context of construction (Li, Irani, & Love 2000), examined the correlation between IT spending and organisational productivity. By analysing 60 consulting companies from the Hong Kong construction industry they found a positive correlation between IT spending and productivity for quantity surveyors and architectural firms, whereas for engineering firms they found little evidence of a positive correlation. (Brynjolfsson 1993) identifies several reasons, which have led to the rise of the productivity paradox, and one of the identified problems is the poor adoption of IT evaluation methods.

Some recent surveys show that the Danish construction industry is a business area where a significant amount of money is spent on IT (Andresen 1999;Howard 1998a;Howard 2001). One of the findings from these surveys is that most architects in 1998 spent between 1-2% of their turnover on IT, consulting engineers between 2-4% whereas contractors spent between 0-0.5% (Howard 1998a). The reason why contractors spent a lower percentage of their turnover on IT than the consultants, is primarily because of the way turnover is calculated. For contractors the turnover includes the whole value of the building project (e.g. building materials) whereas the consultants' turnover is calculated on the basis of their fee for designing building projects.

Comparing the IT Barometer surveys in 1998 and 2001 shows a general increase in IT spending. Most architects now spend approximately 5.3% of their turnover on IT, consulting engineers approximately 4.5% and contractors approximately 1%. All three groups of companies have thereby increased the amount invested in IT.

Considering that the average spending on IT in year 2000 is agreed to be 5% for consultants and 1% for contractors it is possible to calculate the two groups' spending on IT if the turnover is known. *Table 1* shows the approximate investment in IT for consultants and contractors in the Danish construction industry in the year 2000 when based on the numbers given above and turnover data from (Erhvervsfremme Styrelsen 2000).

[1] The IT productivity paradox is questioning whether the usage of IT improves a company's productivity
[2] The word *lost* seems to be odd in this context, but is used because the source uses it

*Table 1. Rate of IT investment made by consultants and contractors for year 2000*

| | Consultants[3] | Contractors |
|---|---|---|
| Turnover (million DKK[4]) | 11,702 | 67,285 |
| IT investment percentage | 5% | 1% |
| IT investment (million DKK) | 585.1 | 672.9 |

In total the approximate investment in IT for the year 2000 was 1.23 billion DKK for consultants and contractors in the Danish construction industry. The large investment in IT is becoming a concern for the companies' top executives and the pressure for finding appropriate measures for evaluating the performance is increasing (Remenyi, Money, & Twite 1995). Making this even worse is that IT investments are getting progressively more difficult to assess (Ref: Peters 1988).

Cross-industrial surveys show that an increasing amount of money is invested in IT each year (Willcocks 1996) and this tendency is not expected to be changed in the near future. For example, in the UK alone, there was an estimated spend of £44.4 billion on IT in 1998 (estimated by increasing the 1997 investment by 5% - and this percentage is rather pessimistic). Other sources expect an increase of 10% per year (Willcocks & Lester 1999). Using a wide definition of IT (including voice telecommunications, special-purpose computer equipment like automatic teller machine and customer expenditure on their own information systems personnel) (Moschella 1997) suggests a world market for IT of $3 trillion by the end of 2005.

It is generally argued that companies should assess the *Value for Money* from their IT investments. *Value for Money* is a term used in many contexts but is, in this thesis, related to the costs and benefits of using IT in companies from the construction industry. Identifying the *Value for money* from the IT investments requires that companies from the construction industry evaluate their IT investments by deploying a method (or series of methods) or set of procedures, for how to evaluate the company's IT investments (Carter, Thorpe, & Baldwin 1999;CICA & CIRIA 1995;Remenyi, Money, & Twite 1995;Willcocks & Lester 1994). Several approaches can be identified ranging from the very informal "act of faith" to very formal, advanced and holistic methods that use several criteria in the IT evaluation.

Conducting IT evaluations is, at first sight, rather simple but is in practice often complicated for several reasons (the list is not held to be complete).

- **The development of new IT, both hardware and software, is very fast**
  Both hardware and software are being developed at an amazing speed. Each year the computing power and the number of new software tools are increasing explosively. Moore's Law (from 1965), that states that computing power would rise exponentially, is still valid and implies that more detailed calculations and simulations are now possible. The Internet is the source for new types of software tools like Projectweb, e-Portals, e-commerce etc. Together all these technology developments cause companies from the construction industry to fall behind because they are not able to implement these IT systems at the same speed, moreover the companies have no time to complete IT evaluations because this would delay them even further.
- **Changes in the business are constant and massive**
  Companies are constantly facing changes in their business through technology development,

[3] Consultants, in this context, consist of architects and consulting engineers
[4] $1 was approximately worth 8.3 DKK on 07/09-01

(de)regulation, globalisation, competitors etc (Betts 2000). Some of these changes are not directly controllable and result in daily changes in the way the company competes and in its business activities. Evaluating IT investments separately from these massive changes is very difficult because they cannot be considered as independent from each other. In practice IT managers often experience these changes as not separable and view this as a massive barrier when trying to evaluate a new IT investment.

- **IT is impacting the whole company**
  Today IT is used in almost all of a company's business activities and very few are not affected by IT (if any). Both the board of directors, who benefit from IT by achieving more accurate and timely information on the company's current state, to the cleaner, who checks in and out using a computer, are affected by the use of IT. All levels in a company are to some degree impacted by IT. Also by implementing new IT investments changes will, most likely, also occur in business activities not directly related to the tasks associated with the IT investment (often called the second order effect). The impact of an IT investment is therefore not easily identified and measured, which results in difficulties in evaluating them.
- **The diffusion of IT evaluation methods is low**
  Although there exist many IT evaluation methods their spread is low. Companies from the construction industry are, when they evaluate their IT investments, at best completing a cost/benefit analysis even if the IT investment is of a highly strategic character. This is despite the fact that there exist methods capable of evaluating such IT investments which are better than cost/benefit analysis. Two aspects are relevant in this context, first, the companies' knowledge of the available methods is low and, second, the available methods are not good enough to fulfil the actual need. Evaluating IT investments is, because of these bad conditions, difficult for companies from the construction industry.

Four reasons have been described above which all have some influence on companies from the construction industry's IT evaluation practice. In the present thesis only a small area of the larger picture (as described above) has been addressed. This is because a Ph.D. thesis is not meant to focus on many topics but rather on defining, describing and analysing a small topic in a more thorough manner than is possible if many topics are examined.

## *1.1 Problem statement*

In this thesis the overall mission is to provide valuable knowledge about how to manage IT investments which can support companies' IT usage in the Danish construction industry. Many research topics can relate to this mission and all of these are regarded as important for innovation in the construction industry. There is however a practical limitation on the scope for a research project of this scale. For this reason a more detailed description of the problem statement is enclosed in this section.

Today companies from the construction industry are evaluating their IT investments and existing IT systems in a very informal way. This implies that most companies are justifying their IT expenditure on the basis of what could be called "acts of faith". This might be combined with an analysis of the direct costs associated with the IT investments and existing IT systems, and is at best done by completing a cost/benefit analysis.

IT evaluations are often not completed at more than one stage of the IT investment's life-cycle which implies that only a fractional knowledge of the IT investment's value to the company is known. Often IT evaluations are completed at the initial stages and in the later stages only if a problem occurs. This IT evaluation practice is naturally poor because the benefits (and for that matter the costs) are not quantified and measured and the company is, because of this, not aware of

the realised benefits and costs. In such cases the company must rely on vague feelings on the IT investment's value and this is clearly odd considering the significant amount of money spent on IT.

Ideally companies should evaluate their IT investments and existing IT systems so that their value (as seen from the company's point of view) is identified. This is done by evaluating IT investments in all of their major stages using criteria matching the company's value definition and by using formal methods. A small explanation is needed to support this statement. First, in order to manage the IT investment throughout its lifetime, it is necessary to evaluate it during the major stages it runs through (e.g. choosing IT application, implementation, on going usage etc.). Doing this requires different emphasis (criteria) on the completion of IT evaluations because each of the major stages is radically different in its purpose. Choosing different criteria matching the requirements of the evaluation stage and the company's value definition will therefore give a better knowledge of the actual state of the IT investment. Lastly it is considered necessary to use formal IT evaluation procedures because a certain degree of objectivity is desirable when completing IT evaluations. Using informal IT evaluation procedures (e.g. acts of faith and subjective statements) is very dependent upon the person evaluating the IT investment and might very well result in a different conclusion if done by another person or at another time.

Several developments need to occur if the ideal is to be reached.

- It requires a more dynamic view on why, how and when to evaluate IT than is the case today
- Better knowledge of existing IT evaluation methods
- Selecting the best matching method depending on the actual requirements

The three described developments are dealt with throughout this thesis by seeking answers on the following research questions.

Basically the focus in this thesis is on how companies in the Danish construction industry can, and should, evaluate IT investments. This topic is relevant because most focus so far has been on *how* to use IT in the construction industry and less focus on *why* it should use IT, which has led to uncertainties about the effects of IT.

The central research aim in the thesis is therefore defined as follows:

**How should a company in the Danish construction industry choose the IT evaluation method to be used when evaluating their IT investments?**

In order to make this broad-stated research aim useful a series of more detailed questions is given below.

1. How can companies evaluate their IT investments by using IT evaluation methods?
2. How are companies today evaluating their IT investments in the Danish construction industry?
3. What are the experiences and results of using IT evaluation methods in real-life situations?
4. What are the influential parameters when choosing an IT evaluation method in the Danish construction industry?
5. How should a framework for choosing the best matching IT evaluation method be structured and used?

Each of the five questions is described further below.

### 1.1.1 Evaluating IT investments by using formal methods

The first question focuses on how companies can evaluate their IT investments by using the available IT evaluation methods. Different types of method are analysed with regard to their characteristics and thereby how they can be categorised.

Answering this question will give an overview of some of the available IT evaluation methods. By describing and analysing their characteristics and usefulness it will give an insight into how IT evaluations can be completed if these methods are used.

### 1.1.2 Evaluation of IT investments in the Danish construction industry today

In order to improve IT evaluation practice in the Danish construction industry it is necessary to identify how it actually evaluates its IT investments as a first step. In the problem statement (see earlier section) a brief description of the current IT evaluation practice in the Danish construction industry is completed but this focus is also addressed in this question. There are two reasons for that: (a) to confirm the description of the current IT evaluation practice in the Danish construction industry and (b) to examine in greater detail how companies from the construction industry evaluate their IT investments.

The answer to the second question will provide a guide to the companies in the Danish construction industry about how they are positioned with regard to their evaluation practice for IT investments compared to the general practice.

### 1.1.3 Using IT evaluation methods on concrete case studies

Having answered the first and second questions, the next step is to use different IT evaluation methods on case studies in order to examine how IT evaluations can be completed by using different methods.

The experience and results from completing case studies, that focus on IT evaluations, can give an insight into: (a) the used IT evaluation methods, (b) actual evaluations of IT investments with relevance to the construction industry, (c) the practical problems experienced when completing IT evaluations and (d) the influential parameters on the IT evaluation.

### 1.1.4 Identification of influential parameters for evaluation of IT investments

What are the influential parameters on how an IT investment or existing IT system should be evaluated? Several groups of parameters are needed when identifying the relevant parameters because it is not beneficial to evaluate IT investments and existing IT systems without evaluating their context (Farbey, Land, & Targett 1995a;G.Khalifa, Irani, & Baldwin 1999;Pedersen & Larsen 2000;Smithson & Hirschheim 1998). In other words it is not beneficial to evaluate an IT investment without including the context surrounding it. This identification can be done, with advantage for the construction industry, because of special characteristics that makes it different from others.

The output from the fourth question will contain information regarding the important and influential parameters in the evaluation of IT investments and existing IT systems. The identified parameters' attributes will provide a basis for how a company from the Danish construction industry should evaluate an IT investment or an existing IT system.

### 1.1.5 The framework for selection of the best matching IT evaluation method

Which IT evaluation method should a company from the construction industry use? This question is addressed in this research question. Choosing the best matching IT evaluation method cannot be done simply and has to be chosen using characteristics of the specific situation. The framework should be based on the influential parameters' attribute(s) (identified in the previous question) and then by matching this with the available IT evaluation methods.

Such a framework has earlier been proposed by (Farbey, Land, & Targett 1993), but their framework is found to be very difficult to use in practice. This framework has been used, in the last two years, in a course called, *Management of IT in a construction company*, by a number of students to select an IT evaluation method. They all found the framework to be difficult to complete and the framework's output difficult to use. It is a further problem that it is not related to the context of construction.

The answer to the last question establishes a connection between the influential parameters' attribute(s) and the existing IT evaluation methods. This will provide a framework for how a company in the Danish industry should select an existing IT evaluation method and will give important information on why this method should be used.

## *1.2 Benefits of thesis*

It is not the intention in this section to describe in detail the benefits of a framework that enables a user to identify the best matching IT evaluation method. However, a short description of the thesis' benefits is in place in this section.

Two groups would mainly obtain benefits from this thesis: The research society, who focus on improving the usage of IT in the construction industry, and the real-world practitioners, who are daily facing difficulties when managing and evaluating the company's IT investments.

The research field will, with this thesis, have gained a better understanding and greater awareness of the subject: evaluating IT investments in the construction industry. Throughout the chapters in this thesis new knowledge is presented related to this subject and this might be beneficial to some researchers. First of all a higher awareness of the importance of the subject is beneficial because it, from time to time, is important to recall why we are doing research in IT usage in the construction industry. Secondly, better knowledge and understanding of costs and benefits of IT investments in the construction industry can be used to provide guidelines for future research areas not currently understood.

IT managers in the construction industry will, with this thesis and the framework, be able to improve their IT evaluation practice by enabling them to choose the best matching IT evaluation method. The ultimate effects of this improved IT evaluation practice are an increased ability to identify and manage the most beneficial IT investments, and a greater knowledge of the value achieved through IT usage in the company. The framework will not solve all the problems but form a part of a greater tool for improving the companies' IT evaluation practice, which should lead to a better optimisation of their future IT investments and a better understanding of their existing IT systems.

## 1.3 Hypotheses

Two central hypotheses are tried proven in this thesis.

**There is not one best IT evaluation method for all cases.**

This hypothesis claims that one IT evaluation method cannot alone fulfil all the requirements necessary in every possible IT evaluation. Two statements are derived from the first hypothesis.

- The available IT evaluation methods are fulfilling different requirements
- Evaluations of different IT investments require different IT evaluation methods

The second hypothesis is a sequel to the first hypothesis. If the first hypothesis is not valid then the second hypothesis cannot be valid either.

**The use of the framework for the identification of the best matching IT evaluation method for an IT investment improves a company's IT evaluation practice.**

Companies from the construction industry can, by using a framework for how to select the best matching IT evaluation method, improve their IT evaluation practice by the company:

- Having a greater awareness of available IT evaluation methods
- Using more formal IT evaluation procedures than today
- Considering more parameters when choosing an IT evaluation method
- Being able to choose the best matching IT evaluation method

## 1.4 Definitions used in the thesis

This section contains the definition of the central keywords used throughout the thesis. The definitions will only be explained in this section and it is, for the rest of the thesis, expected that the reader is familiar with these.

The first and most fundamental definition used throughout this thesis is about IT. Many definitions have been suggested by various researchers and all of them can be useful within a certain context. Traditionally there has been a differentiation between IT and information systems (IS) but, in this thesis, these are not differentiated from each other. Therefore IT refers to the hardware, software and communications technologies – essentially equipment – and attendant techniques and how designed information flows attempt to meet the information needs of the organisation. (Willcocks & Lester 1994). In other words IT is about computer-based systems that handle information useful to a company.

The second definition is also regarded as fundamental to the thesis. IT evaluation is composed of two aspects: IT (see above) and evaluation. Evaluation has been defined as “a series of activities incorporating understanding, measurement and assessment. It is either a conscious or tacit process, which aims to establish the value of, or the contribution made by, a particular situation.” (Remenyi, Sherwood-Smith, & White 1997). Combining the two definitions shows that IT evaluation is a series of activities, which aim at establishing the value or contribution made by a particular IT investment.

The above definition includes the word value which also needs to be defined. In general different IT evaluation methods use an implicit definition which is unique compared to the other methods. It is therefore not possible to define value precisely as this depends on the method. One IT evaluation method is mentioned, Information Economics, as it emphasizes the meaning of the word. “Value is based on advantage achieved over the competition, reflected in current and future business performance. That which will add to the advantage over the competitors of a firm is the value in which management should be willing to invest.” (Parker & Benson 1988).

Another related keyword is the impact of IT investment. It is defined as all the changes that are directly and indirectly occurring in a company as a consequence of the IT investment. This includes both negative and positive changes in the company[5].

An IT evaluation method is, in the thesis, referring to a tool, methodology or set of procedures that completes an IT evaluation. They may consist of either informal or formal IT evaluation procedures. Informal IT evaluation procedures refer to ill-informed, hasty and largely subjective judgements whereas formal IT evaluation procedures are objective, rational mechanisms aimed at improving the communication and learning within the organisation (Smithson & Hirschheim 1998).

## 1.5 Limitations

Firstly, evaluating IT investments in companies from the construction industry is, in a broad sense, very extensive ranging from examining the technology fit into the company’s IT architecture, to identifying the requirements (functionalities) of the IT investment, to quantifying the economical costs and benefits of using the IT investment, etc. The focus in this thesis is primarily on assessing the costs and benefits of a company’s IT investments. Costs and benefits are, in this thesis, understood in a broader context than just those that are economically measurable.

The following types of IT evaluation are not included in this thesis.

- A company’s need for IT systems
- Technology’s fit into an existing IT environment
- Very small IT investments (e.g. like buying a single licence for a software package)

Even though the definition of IT evaluation is limited in scope in this thesis, some of the methods examined focus on several aspects of IT evaluation which, in some cases, exceed the limitations of the definition. The primary focus is nonetheless on evaluating the costs and benefits of IT investments and the evaluation methods used are completed according to their original intention as long as the primary focus is fulfilled.

Secondly, the developed framework is only based on four different IT evaluation methods even though many more exist. Including all the available IT evaluation methods is theoretical desirable but is in practice impossible considering the time limitations. This is complicated even further because of the increased number of newly developed methods each year which would make the framework incomplete before the thesis has even been published. The chosen methods are, however, not selected randomly from the available methods, but each method is chosen because it represents a larger number of methods with some of the same characteristics. This is further commented on in chapter 3.

[5] Whether a change is regarded as positive or negative is dependent upon who is the viewer

## 1.6 Scientific method

Different types of approach in completing an investigation can be mentioned depending on the criteria used. One example of differentiating investigations is presented by (Andersen et al. 1994). In their point of view four different types of knowledge-based purposes can be defined (see *Figure 1*).

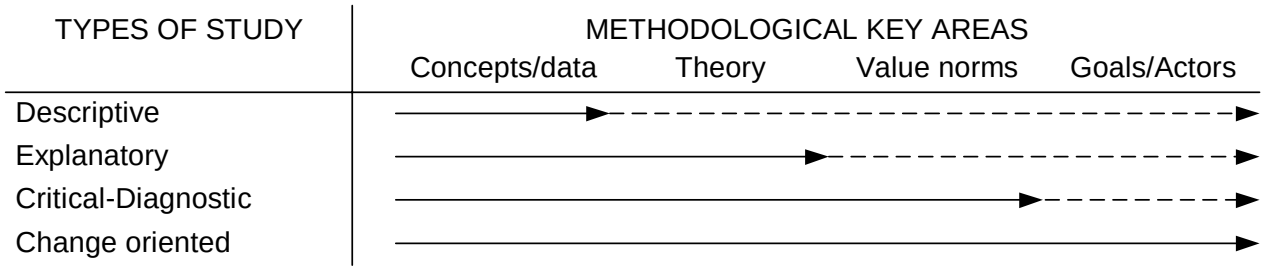



*Figure 1. Different types of research projects (Andersen et al. 1994)*

Each type of knowledge-based purpose is briefly described in the following.

- **Descriptive**
  This purpose aims at describing the phenomenon with regards to its scale, scope, context etc. This is often done by answering questions starting with words like what, when, where, whom etc. A general characteristic of this type of investigation is that it, to some degree, appears in most projects and investigations.
- **Explanatory**
  Investigations and projects of this kind focus in a simplified sense on answering questions beginning with the word *why*. To ask this question requires a model or theory that either predicts or explains a concrete phenomenon. The model or theory used needs to be associated with data that describe the predicted or explained phenomenon (see the previous section).
- **Critical-Diagnostic**
  A critical-diagnostic investigation or project is characterised by the realisation that a phenomenon is not in a desirable state. The focus is on describing the wrong state of the phenomenon, why the phenomenon is in this state and identifying what the alternative solutions are. The critical aspect is not only focused on the models or theories dominating the phenomenon but also on the phenomenon itself.
- **Change oriented**
  The last type of knowledge-based purpose is characterised by the researcher being involved in changing the investigated phenomenon by initiating actions himself. The relationship between theory and practice is close and needs to be managed so that one of them is not becoming dominant.

The four knowledge-based purposes described above are either explicitly or implicitly completed in an investigation or project and it is therefore necessary to identify which purposes are explicitly and implicitly addressed in order to describe the methodology used in the research project.

This thesis describes a research project that is characterised as having a Critical-Diagnostic knowledge-based purpose. This implies that the following three activities are explicitly addressed in the thesis.

- Description of the phenomenon
- Identification of an explanation of the current state of the phenomenon
- Development of a solution

Implicitly the following activity needs to be considered in the thesis but is not included as a part of it.

- Implementing a solution

In the previous paragraphs the types of investigation and project were identified and some guidelines were derived from the identification of the project's type of knowledge-based purpose adopted. The second step in describing the scientific method used in the research project, is the adopted scientific approach.

A scientific approach is characterised by a sequence of stages in which the primary aim is achieving new knowledge about a phenomenon. *Figure 2* shows the stages in a general scientific approach that focus on solving a problem (Critical-Diagnostic) and this is used in many research projects.

Common to Critical-Diagnostic research projects is the development of a solution on the basis of models, theories and data that solve an identified problem. The solution is then afterwards tested according to a hypothesis that is finally validated.

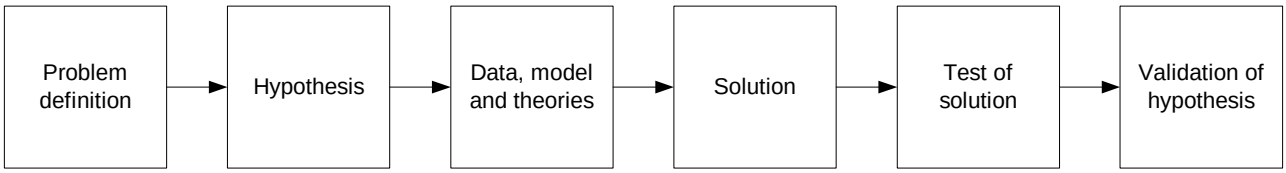



*Figure 2. General scientific approach*

Each stage completed in the general analytical-empirical scientific approach is, in the following, explained briefly with relation to the present project as presented in this thesis.

- **Problem definition**
  In the first stage the problem is defined with regard to what the identified problem is and how it can/should be solved. This stage has already been described in a previous section which states that the identified problem is about how companies from the construction industry should evaluate their IT investments.
- **Hypothesis**
  A hypothesis is proposed at this stage so that it can be used as a guideline for the research project and the test of the framework. The hypothesis is, in this project, claiming that if the framework is used then the companies IT evaluation practice will be improved (for further details see earlier section).
- **Data, model and theories**
  This stage focuses on assembling and gathering data which are used to develop the solution together with the already developed models and theories representing the phenomenon investigated. Some methods for how to evaluate IT investments are investigated and a questionnaire survey and a series of case studies are completed in the project in order gather data which can be used to develop the framework.
- **Solution**
  A solution, or a number of solutions, to the identified and described problem (phenomenon)

is developed and described on the basis of the established theories and models plus the gathered empirical data. The solution is primarily a framework for how a company from the construction industry can select the best matching IT evaluation method.

- **Test of solution**
  The proposed solution is tested with regard to its usability in solving the described problem (phenomenon) defined. The framework is tested at this stage for its usefulness for selecting the best matching IT evaluation method.
- **Validation of hypothesis**
  The last stage is focused on validating the hypothesis by comparing the new state with that expected. The consequences of using the framework is analysed and compared with the hypothesis. If the framework leads to the state that the hypothesis predicts then it is validated.

In the following chapters the present thesis will be directed by the stages described in the above paragraphs. By this stage both the problem definition and hypothesis have been presented.

## 1.7 Target readers

The primary reason for completing this thesis is to obtain the Ph.D. degree, which means that the primary target readers of this thesis are the people in the censor board who are judging this thesis. These people represent a variety of background knowledge and require a focus on both theoretical and practical issues.

The second target readers are the IT managers employed in a wide variety of companies from the construction industry. These are the people who have to understand and appreciate the subject. Furthermore, and maybe most important, these are the people who are supposed to use the findings and recommendations presented in this thesis.

## 1.8 Structure of thesis

The thesis has been divided into 13 chapters generally following the process as described in the section about the scientific method.

Chapter 1: *Introduction* (the present chapter), contains a description of the problem statement, the hypotheses, the limitations and the scientific method.

The first part of the thesis is called, **State of the art**, and contains, chapter 2, 3 and 4. These chapters together describe the current state of both research and practice in the subject of IT evaluation.

Chapter 2: *IT evaluation methods*, gives an overview of existing IT evaluation methods by listing a number of them. The characteristics, which can be used to describe their similarities and differences, are identified. Lastly a proposal, which is derived from a literature review, for how to categorise the methods, is presented.

Chapter 3: *Four IT evaluation methods*, describes the selection of four IT evaluation methods from the list of methods identified in chapter 2. The four methods are described in details with regards to their structure, their characteristics (based on those identified in chapter 2), strengths/weaknesses and lastly a description of how they can be used in practice.

Chapter 4: *Survey of IT evaluation in the Danish construction industry*, presents the findings from a questionnaire survey, completed in 1999, that focuses on how companies from the construction industry evaluate their IT investments throughout the different stages of their life-cycle. The general level of the companies' IT evaluation practice is commented on the basis of the findings in the survey.

This second part of the thesis called, **Case studies**, contains chapter 5 and 6. They describe a number of case studies completed.

Chapter 5: *Case study descriptions*, describes the selection, and methodology, used in five case studies with companies from the construction industry. The purpose of completing the four selected IT evaluation methods on real-life IT evaluations is explained. Three aspects are described in relation to each case study; the company, the IT evaluation and the IT investment. Together this gives a detailed insight into the five case studies.

Chapter 6: *Output from the four IT evaluation methods*, presents the output from the four IT evaluation methods in each of the five case studies. Each of the four methods has provided output which can be used to assess the IT investment's desirability with regard to, for example, financial value, strategic benefits, risks etc. Based on the output provided by the methods, the direct derivable conclusions are commented upon.

The third part of the thesis called, **Analysis**, contains chapter 7, 8, 9 and 10. These chapters are together describing the analysis of the data collected in the two first parts.

Chapter 7: *Case study analysis*, firstly, describes the practical problems experienced by the IT managers from the construction industry. Secondly, the strengths and weaknesses of the four methods are presented together with an identification of the best method found in each case study. Thirdly, two case studies completed in the UK are described and the output from an IT evaluation method are commented on and compared with the Danish case studies. Lastly, an identification of parameters that have an influence on the choice of IT evaluation method is presented.

Chapter 8: *Identification of the influential parameters*, presents a complete list of the influential parameters that have an influence on the choice of IT evaluation method. It proposes a system for how to categorise the parameters and each parameter is described according to the context in which it was identified and how it was identified.

Chapter 9: *Description of the parameters*, defines each of the identified parameters and describes the attributes that can be assigned to it. Lastly the potential overlap between the parameters' attributes is discussed.

Chapter 10: *Relationship between the attributes and the methods*, describes the relationship between the parameters' attributes and each of the four methods based on a set of usability scores that is defined in the chapter. Each of the five case studies is commented with regard to the parameters' attributes.

The fourth part of the thesis called, **Results**, contains chapter 11 and 12. These chapters are describing the implementation and testing of the framework.

Chapter 11: *Using the framework*, describes two versions of a framework that can be used to identify the best matching IT evaluation method. The two versions developed are a paper-based

version and a software-based one (using a developing tool for designing expert systems called, *Kappa*). The paper-based version will be the main version described in the chapter as this enables more detailed explanations of the framework. A small example is completed in order to exemplify how the paper-based version should be used. Lastly a description of possible output from the framework is commented on.

Chapter 12: *Testing the framework*, tests the framework on the five case studies which have been described in chapter 5. The output provided by using the framework in each case study are compared with the experience gained when completing the four methods in the case studies. The comparison is used to identify whether the framework reflects the experience gained in practice. In the last part of the chapter the involved IT managers from the case studies gives their comments on the framework on the basis of a demonstration.

Chapter 13: *Conclusion*, validates the hypotheses stated in chapter 1 based on the findings presented throughout the thesis' chapters. The five research questions are answered leading to the answer to the central research aim. The influences and relevancies of the assumptions and limitations made throughout the thesis are discussed. Lastly, the possibilities for further research and commercial adoption of the findings of the thesis are presented.

# Part I

# State of the art

The availability of IT evaluation methods, their characteristics and a categorisation are presented and discussed. From the list of methods four are chosen and described in detail. These are later used in a number of case studies with the purpose of collecting the empirical data needed in the framework development. Lastly a survey identifying current IT evaluation practice in the Danish construction industry is presented and analysed.

# Chapter 2: IT evaluation methods

In this chapter the aim is to give an overview of the availability of existing IT evaluation methods and to describe their general characteristics. From the description of the methods a way of categorising them is presented.

The first part of the chapter describes the development of IT compared with the changes in companies' IT evaluation practice. This gives a better background for understanding why companies do as they do with regard to their IT evaluation.

The second part of the chapter presents a number of IT evaluation methods that have been identified through a literature review. The list of IT evaluation methods will, later in this chapter and in chapter 3, be used to describe their similarities and differences.

The last part of the chapter identifies the characteristics used to differentiate the IT evaluation methods, and different ways of categorising the methods are presented ending up with a categorisation of the methods listed in the first part of the chapter.

## 2.1 The history of IT evaluation in the context of computer developments

Computer technology has, since the first computer was developed in 1948[6], undergone an incredible development exceeding all other developments during this period. The commercial computer has been implemented in a growing number of companies worldwide and hardly any company in developed countries can avoid using IT today.

A short description of the main developments in computing is given below together with the changes in the companies' IT evaluation practice. The descriptions are mainly based on the work by (Moschella 1997) and (Howard 1998b).

**The System Centric era 1964-1981**
IBM S/360 series is today known as the first upgradeable computer. This computer was developed by IBM and released in 1964. IBM was, in this era, the most dominating supplier of commercial computers. In the beginning the control of computing was centralised using mainframes, but due to dissatisfaction by financial departments and because of the availability of microcomputers, it slowly started to decentralise. During this period most computers in the construction industry were used in research but, in the late seventies, the first CAD systems were used commercially.

In this period most companies justified their IT expenditures through an improved company image to the customers. The companies had very little interest in completing IT evaluations as IT investments were often considered as experiments rather than investments. Through this period the difficulties of monitoring IT costs were found as the usage of IT slowly became more and more decentralised.

[6] It has often been debated when the first computer was developed, but this is more a discussion about how the definition of a computer should be rather than who was the first

**The PC Centric Era 1981-1994**
In 1981 IBM released the personal computer called IBM PC empowered by the operating system, MS-DOS, developed by Microsoft. Through the following years the PC was used in a steadily growing number of areas. During this period CAD systems were becoming more widely used in the construction industry but were still very expensive. In general the cost of computers decreased significantly in this period, because by the growing demand.

The companies were, during this period, beginning to face difficulties with justifying their still increasing expenditures on IT. Many new IT evaluation methods were therefore developed during this period (see also the list of methods in *Table 2*), as it was slowly realised that the existing methods were inadequate (at that time they were primarily financially oriented methods). A loosening of financial justifications was occurring, because of difficulties in, or lack of concern for, verifying the claimed benefits from investment in computers. This led to the justification of IT investments often being done as an act of faith (Farbey, Land, & Targett 1992).

**The Network Centric Era 1994-2005**
This period is characterised by a changed focus from local area networks (LANs) to wide area networks (WANs) (Willcocks & Lester 1999). The development in networking computers is exploding, primarily because of standardisation and commercial interest. Many companies see the potential benefit in reducing the transaction costs through electronic commerce and that might lead to another rise in computer spending. An increased focus on sharing information through using computers is occurring in the construction industry as one of the main objectives of IT usage.

A plethora of IT evaluation methods is available but companies are not adopting them and tend to cling to the financial appraisal methods used in other types of investments (if they evaluate their IT investments at all). Top managers are increasingly requiring better justification of the companies' IT expenditures as IT is viewed as just another possible investment. The companies are trying to improve their IT evaluation practice, but are still facing serious problems.

**The Content Centric Era 2005-2015**
The IT development in this era is, as predicted by (Moschella 1997), to go from wired consumer to individual services and from electronic commerce to virtual businesses. Companies will not revolve around any particular technological capability but will focus on community or audience[7] that has a particular set of needs and interests. The spread of the computer will be worldwide. In the context of construction the sharing of information on building projects will be done by a common building model and libraries of data needed to design and construct.

The future of IT evaluation is difficult to predict but there is a trend indicating that evaluating the cost of technology will be less important (primarily because costs of hardware and software are still decreasing) whereas the social dimension of IT evaluations will be emphasized.

The cycles of IT developments, as described above, are illustrated in *Figure 3*, together with the main characteristics of each cycle with regard to the type of technology used. For each of the identified cycles the usage of IT is radically different from the others, which also implies a further complication of the companies' IT evaluation practice.

[7] Audience is defined broadly in this context to include various consumers, a business or even an industry.

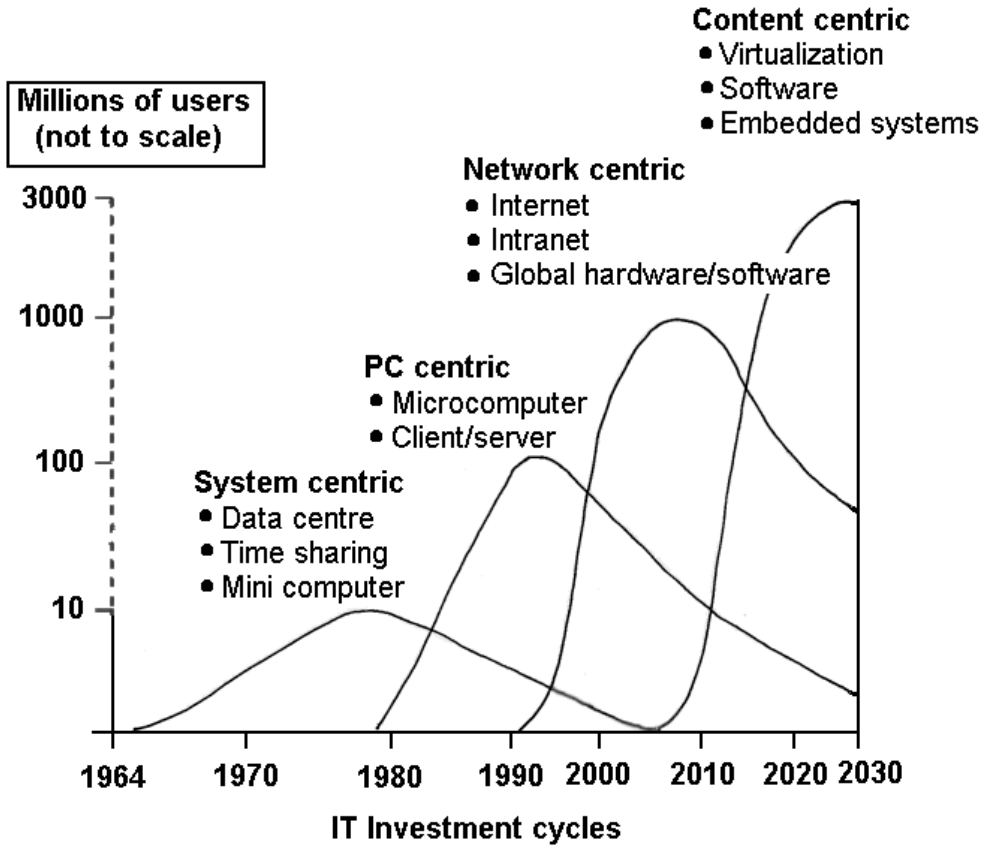



*Figure 3. IT investment cycles (Moschella 1997)*

In *Figure 3* it is worth noticing that the cycles (or main developments) are overlapping. Since 1991 three cycles are crossing each other and this implies great demand for companies' IT evaluation practice. This is because each of the described cycles has its own need for how IT investments should be evaluated and the companies therefore experience difficulties when evaluating their IT investments as they have to be able to differentiate between three ways of using their IT investments.

The development of IT has, over time, changed the way that companies explore the benefits of IT. A way of illustrating the change in commercial use of IT can be seen in *Figure 4* (Remenyi, Money, & Twite 1995). The different types of main impacts from using IT have had a significant influence on how the companies have evaluated their IT investments and they are therefore relevant when considering the appropriateness of a company's IT evaluation practice. Three periods are described briefly in the following.

**1950's: Efficiency through Automation**
The first major impact by computers was automating existing work processes. The computer was able to perform some operations much more efficiently than people could (quicker and with less errors). This means that labour intensive work could be reduced by replacing, for example, clerical work with computers. This type of impact is still relevant, and is normally considered as the direct benefit of the IT investment. A typical example is payroll systems.

**1970's: Effectiveness through Information**
The second impact in focus during the 1970's is called effectiveness because it is about performing the right things and not just in the right way. In other words it means to improve the effectiveness of the existing business processes by completing them in a different and more efficient way. Management of information is the central theme in this area. The company's managers are able to improve the organisation's efficiency through making better information available, like Decision Support Systems (DSS).

**1980's: New Business Processes through Transformation**
In the 1980's IT was more commonly being used as an enabler of new business areas. A transformation or creation of new business activities in the organisation is the impact in focus. Companies that wanted to expand or change their business activities could use IT as an enabler to these changes by changing the output of the company's business activities. An example of such a change is Electronic Data Interchange (EDI).

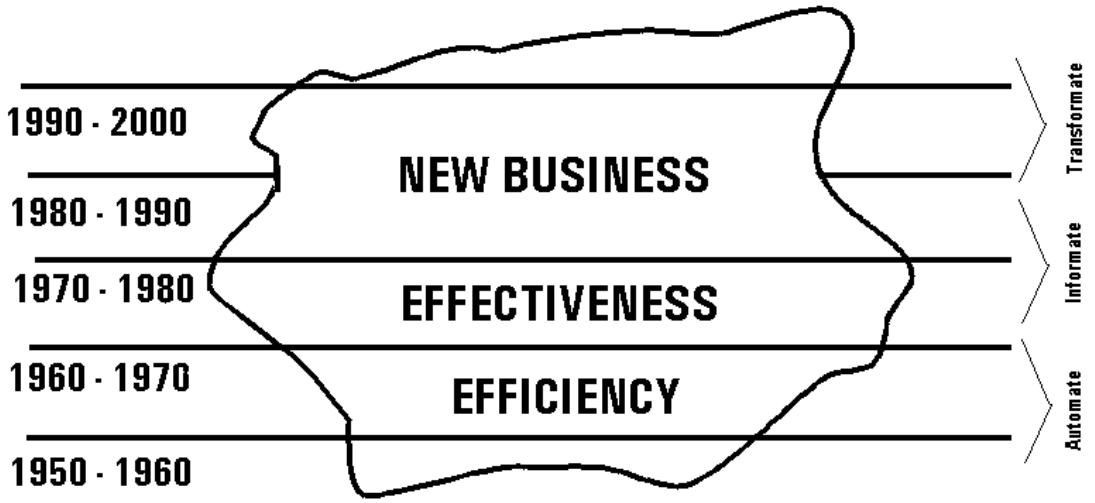



*Figure 4. Development of IT usage (Remenyi, Money, & Twite 1991)*

Each of the major impacts from IT requires a different approach when evaluating IT investments. For example, IT investments in which the major impact is automation should be evaluated by using financial IT evaluation methods, whereas the other two impacts require more complex methods as their usage also has an influence on the evaluation output.

During the decades of IT developments, which have been described, the development of IT evaluation methods began as a major issue in the sixties. In 1961 the International Federation of Information Processing devoted a conference to topics about evaluation issues and E. O. Joslin published a book called "Computer selection" in 1968 (Renkema & Berghout 1997).

## 2.2 An overview of existing IT evaluation methods

A few researchers have given an overview of the available methods for evaluation of IT investments (Farbey, Land, & Targett 1993;Powell 1999;Remenyi, Money, & Twite 1995;Renkema & Berghout 1997). The list of methods has been generated on the basis of a literature review. An extensive number of IT evaluation methods have been identified and they are all different in some

ways, although (this is discussed in the next section). A list of identified IT evaluation methods is shown in *Table 2* together with the original source if possible.

| | |
|---|---|
| Accounting Rate of Return (ARR) | (Bacon 1992) |
| Analytic hierarchy process | (Saaty 1980); in: (Carter 1992) |
| Application benchmark technique | (Joslin 1965); in: (Powell 1999) |
| Application transfer team approach | in: (Lincoln et al. 1990) |
| Automatic value points | in: (Lincoln et al. 1990) |
| Balanced scorecard | (Kaplan & Norton 1992) |
| Bayesian analysis | (Kleijnen 1980) |
| Bedell's method | (Bedell 1985) |
| Buss's method | (Buss 1983) |
| Benefits-risk portfolio | (McFarlan & McKenney 1983) |
| Benefit assessment grid | (Huigen & Jansen 1991) |
| Bradford Information System Evaluation Method | (Wolstenholme, Henderson, & Gavine 1993) |
| Breakeven analysis | (Sassone 1988) |
| Boundary values (spending Ratios) (BV) | in: (Farbey, Land, & Targett 1993) |
| Business Impact or Time Release Analysis | in: (Remenyi, Sherwood-Smith, & White 1997) |
| Cost Avoidance | in: (Sassone 1988) |
| Cost Benefit Analysis (CBA) | (King & Schrems 1978); (Sassone & Schaffer 1978) |
| Cost Benefit ratio | (Tam 1992) |
| Cost Displacement | in: (Sassone 1988) |
| Cost effectiveness analysis | in: (Sassone 1988) |
| Cost-value technique | (Joslin 1968) |
| Cost-revenue analysis | in: (Farbey, Land, & Targett 1993) |
| Composite and ad hoc methods | in: (Farbey, Land, & Targett 1993) |
| Critical Success Factors (CSF) | (Rockart 1979) |
| Customers resource life cycle | (Ives & Learmonth 1984); in: (Hochstrasser & Griffiths 1991) |
| Decision Analysis | in: (Sassone 1988); in: (Powell 1999) |
| Delphi evidence | in: (Powell 1999) |
| Economic Assessment – I/O Analysis | in: (Remenyi, Money, & Twite 1995) |
| Executive Planning for Data Processing (EPDP) | in: (Lincoln et al. 1990) |
| Functional Analysis of Office requirements | (Schaeffer 1988) |
| Game-playing and role-playing | in: (Farbey, Land, & Targett 1993) |
| A Health Check of the Strategic Exploitation of IT | (Construct IT 1997) |
| Hedonic wage model | in: (Sassone 1988) |
| Information Economics (IE) | (Parker & Benson 1989) |
| Internal Rate of Return (IRR) | (Brealey & Myers 1988); (Fox, Kennedy, & Sugden 1990) |
| Investment mapping | (Peters 1988) |
| Investment portfolio | (Berghout & Meertens 1992) |
| Information Systems Investment Strategies (ISIS) | in: (Lincoln et al. 1990) |
| Knowledge based systems for IS evaluation | (Agarwal, Tanniru, & Dacruz 1992) |
| Kobler Unit framework | (Hochstrasser & Griffiths 1991) |
| Lautanala's method | (Lautanala et al. 1998) |
| Measuring the Benefits of IT Innovation (MBITI) | (Construct IT 1998) |
| MIS utilisation technique* | in: (Powell 1999) |
| Multi Objective Multi Criteria (MOMC) | in: (Farbey, Land, & Targett 1993); (Vaid-Raizada 1983) |
| Net Present Value (NPV) | (Brealey & Myers 1988); (Fox, Kennedy, & Sugden 1990) |
| Option theory | (Dos Santos 1991) |
| Payback period | (Brealey & Myers 1988); (Fox, Kennedy, & Sugden 1990) |

| | |
|---|---|
| Potential Problem Analysis (PPA) | in: (Powell 1999) |
| Process Quality Management (PQM) | in: (Lincoln et al. 1990) |
| Profitability index method (PIM) | (Bacon 1992) |
| Proportion of Management Vision Achieved | in: (Remenyi, Money, & Twite 1995) |
| Prototyping | in: (Farbey, Land, & Targett 1993) |
| Quality engineering | (Hochstrasser 1993) |
| Relative Competitive Performance | in: (Remenyi, Money, & Twite 1995) |
| Return On Investment (ROI) | (Brealey & Myers 1988); (Farbey, Land, & Targett 1993) |
| Return on Management (ROM) | (Strassmann 1990) |
| Requirements-costing technique | (Joslin 1968) |
| Schumann's method* | in: (Swinkels & van Irsel 1992) |
| Satisfaction and priority survey | in: (Lincoln et al. 1990) |
| SESAME | (Lincoln et al. 1990) |
| Seven milestone approach | (Silk 1991) |
| Strategic Investment Evaluation and Selection Tool Amsterdam | (Irsel, Fuitsma, & Broshuis 1992) |
| Simulation | in: (Farbey, Land, & Targett 1993) |
| Strategic application search | in: (Lincoln et al. 1990) |
| Strategic Match Analysis and Evaluation | in: (Remenyi, Money, & Twite 1995) |
| Strategic option generator | (Wiseman 1985) |
| Systems investment methodology | in: (Lincoln et al. 1990) |
| Socio-technical project selection | (Udo & Guimaraes 1992) |
| Structural models | in: (Sassone 1988) |
| System dynamics methodology | (Wolstenholme, Henderson, & Gavine 1993) |
| Systems measurement | (Spraque & Carlson 1982); in: (Powell 1999) |
| Time savings times salary | in: (Sassone 1988) |
| Transformate Model | in: (Remenyi, Money, & Twite 1995) |
| User Attitudes | in: (Remenyi, Money, & Twite 1995) |
| User Information Satisfaction (UIS) | (Miller & Doyle 1987) |
| User utility function assessment technique | in: (Powell 1999) |
| Value Analysis | (Keen 1981) |
| Value Chain Assessment (firm and industry) | (Porter 1985) |
| Ward's portfolio analysis | (Ward 1990) |
| Wissema's method* | (Wissema 1985) |
| Work Study Assessment | in: (Farbey, Land, & Targett 1993) |
| Zero based budgeting | in: (Zmud 1983) |

*Table 2. Alphabetical list of identified IT evaluation methods*

Three methods have been marked with an asterisk which indicates that it has not been possible to retrieve any literature that describes the methods in more detail.

The list of IT evaluation methods shown in *Table 2* is quite extensive (82 methods are listed) but, because new methods are being developed and released almost every day, the list should not be taken as complete. However, not all the methods listed are specifically designed for evaluation of IT investments but may be used for that purpose as well and, lastly, several of the methods can be considered as combinations of other methods.

## 2.3 General characteristics of IT evaluation methods

Each of the listed methods in *Table 2* can be described using different characteristics and these will be identified in the following. Many general characteristics, that describe the methods' similarities

and differences, can be derived by analysing the available IT evaluation methods and these have earlier been identified and described by (Farbey, Land, & Targett 1993), (Renkema & Berghout 1997), (Powell 1999), as seen in *Table 3*.

*Table 3. General characteristics of IT evaluation methods*

| Farbey et al. 1993 | Renkema & Berghout 1997 | Powell 1998 |
|---|---|---|
| ▪ The role of evaluation<br>o Level at which justification carried out<br>o Stage of involvement<br>▪ The Decision environment<br>o Type of benefits<br>o Decision process<br>o Cost of methods<br>o Importance of numbers<br>▪ The system underlying the IT investment<br>o Relation of project to business<br>o Nature of system<br>▪ The organisation making the IT investment<br>o Leadership role<br>o Industry situation<br>▪ Cause and effect relationship<br>o Certainty of impact<br>o Directness of impact | ▪ Objects of the method<br>o Breadth of the method<br>o Type of IT investment<br>▪ Evaluation criteria<br>▪ Support of the evaluation process<br>▪ Type of outcome<br>▪ Quality of IT evaluation methods | ▪ Financial output?<br>▪ Use of questionnaires<br>▪ Probabilities incorporated<br>▪ Range of personnel involved<br>▪ Stage of use<br>▪ Measures operational performance parameters |

The general characteristics of the IT evaluation methods, as proposed by the three sources, are varying significantly in the table, both in number and content. Some of the characteristics are referring to the same aspect of the IT evaluation methods while others are unique.

Three of the listed characteristics, as proposed by the sources, are not considered as relevant to many of the methods because the characteristic is either very subjective in nature or too detailed (it is thereby only relevant for a very small group of methods). These are the following.

- Quality of IT evaluation methods
- Use of questionnaires
- Measures operational performance parameters

The list of characteristics proposed by (Farbey, Land, & Targett 1993) does not refer directly to aspects of IT evaluation methods. For example the characteristic called *Leadership role* that describes a company's competitive position cannot be directly linked to the methods. Such characteristics are, however, still included in the table because they are used by the source to differentiate the methods into subgroups and can thereby be considered as characteristics of the methods.

- Decision process
- Relation of project to business
- Leadership role
- Industry situation

Another characteristic often referred to in the literature is *Company size*. Several researchers have focused on the influence of company size especially smaller companies, (typically referred to as SME's) with regard to IT evaluation, and there is common agreement that this parameter is

important for the company's IT evaluation practice and therefore also the choice of method (Avram 1999;Hillam & Edwards 1999).

### 2.3.1 Identification of parameters in IT evaluation methods

Based on the general characteristics presented in *Table 3*, a combined list of parameters is derived and each parameter is briefly described in the following. The listed parameters are not prioritised and are listed in the order of occurrence as presented in *Table 3*. Whenever two characteristics describe the same aspect of the IT evaluation methods they are listed in the description.

- **Extent of involvement**
  Who is involved in using the IT evaluation method? This parameter is addressed in (Farbey, Land, & Targett 1993) and (Powell 1999) list of characteristics; *Level at which justification carried out* and *Range of personnel involved*. It describes, for example, whether the methods involve one person from the IT department or involve both the board of directors and the IT manager.
- **Stage of IT evaluation**
  Two sources have mentioned the parameter called Stage of IT evaluation. (Farbey, Land, & Targett 1993;Farbey, Land, & Targett 1995a) addresses this in the characteristic; *Stage of involvement*, and (Powell 1999) by using; *Stage of use*. The parameter describes at what stage the IT investment is evaluated.
- **Type of impact**
  Three of the mentioned characteristics are combined in this parameter: *Type of benefits*, *Certainty of impact* and *Directness of impact* (all from (Farbey, Land, & Targett 1993)). The parameter describes the method's usefulness in evaluating different types of impacts achieved from the IT investment.
- **Cost of method**
  How high a cost is allowed in the completion of the IT evaluation method? This parameter is referring to the characteristic used by (Farbey, Land, & Targett 1993). The cost of completing an IT evaluation differs depending on choice of method. The parameter is, however also dependent upon how the method is used.
- **Evaluation criteria**
  Both *Importance of numbers*, *Evaluation criteria* and *Probabilities incorporated* are combined in this parameter. This parameter describes the method's usage of criteria for how the IT investment is evaluated. Examples of different criteria are: financial value, competitive value, effectiveness of use, etc.
- **Type of IT investment**
  The type of IT investment is directly related to the characteristic with the same name in *Table 3* and with the parameter called, *Nature of system*. The parameter describes the methods' usefulness in evaluating different types of IT investments like, for example, IT infrastructure investments or strategic investments. Another aspect of this parameter is whether the method is designed specifically for IT evaluations or all types of investments.
- **Scope of IT evaluation method**
  This parameter refers to the characteristic: *Breadth of method* mentioned in *Table 3*. The parameter is describing the method's scope which is focused on changes in the affected business activities and on the whole company. The scope (or view) used is very important for the output of the evaluated IT investment.
- **Difficulty of IT evaluation method**
  This parameter is referring to the general characteristic: *Support of the evaluation process*. The focus is on how complex the method is which also expresses how difficult the method

is to complete in a specific IT evaluation. It also describes how good is the guidance on how to complete the method.

- **Type of outcome**
  General characteristics referring to this parameter are: *Type of outcome* and *Financial output*. Type of outcome is describing the format of output from completing the IT evaluation methods like, for example, quantitative or qualitative measures that reflect the "value" of the IT investment.

The 9 parameters above are used to describe how the methods differ from each other. The listed parameters can be used to describe a wide range of characteristics of the methods. The method's differences will have an influence on which methods are useful in different IT evaluations and the characteristics are therefore useful when choosing an IT evaluation method.

## 2.4 Classification of IT evaluation methods

All the available IT evaluation methods can, based on the different parameters identified in the previous section, be categorised into different groups which, to some degree, are more related to each other than to the rest of the available methods.

There is not just one possible way of categorising the methods and therefore various researchers have used many different categorisations. For example (Remenyi, Money, & Twite 1995) have categorised the methods depending on their objectivity. They define two groups of methods (a) partially objective and (b) fully subjective based on the assumption that no method can be fully objective. The categorisation is very crude and does not give much clarification about the methods' differences because only one parameter is used.

Another way of categorising the methods has been proposed by (Farbey, Land, & Targett 1993). They have divided a list of known methods into two main groups: *Quantification and comparison* and *Exploratory and experimental techniques*.

The argument for this categorisation is that the first group is based on data collection and is primarily used to determine the costs and benefits of IT investments under consideration. In ex ante evaluation the problem is estimating costs and benefits, whereas in ex-post evaluation the problem is to identify costs incurred and benefits achieved and to determine the extent to which these were the outcome of the changes under consideration.

The second group is primarily used for decision support in choosing the right IT projects. In ex-ante evaluations, with decisions that justify going ahead with the IT investment, and in ex-post evaluations, it is used to provide retrospective justification that the IT investment had indeed been worthwhile.

They argue that these two categories of methods can be separated because data collection methods provide inputs to decision-making whereas many decision-making methods include the decision-making component within the method. Although this is a more sophisticated way of categorising the methods than that previously described, it still only results in two groups of methods, which implies that the methods have many differences even though they are categorised in the same group.

In a later chapter in the same publication (Farbey, Land, & Targett 1993) they categorise the methods into four groups using two dimensions. The first dimension is labelled Role of IT that focuses on the nature of the evaluated IT application. Two characteristics are defined in this dimension; conservative and radical. The other dimension, labelled Evaluation constraints, focuses

on how well-defined the IT evaluation is. This dimension is further divided into two characteristics: well defined and fuzzy. The two dimensions and their characteristics are shown in *Figure 5*.

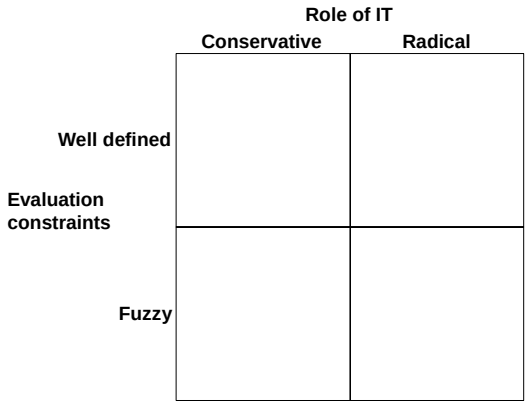



*Figure 5. Categorisation of methods (Farbey, Land, & Targett 1995b)*

By defining two characteristics for the horizontal and vertical dimension (as shown in *Figure 5*) they have four different groups of IT evaluation methods. The four groups are described in the following on the basis of the descriptions provided by (Farbey, Land, & Targett 1995b).

- **Conservative and Well defined**
  This group of methods is characterised as having a single purpose, involving a single rational decision-maker and is useful in organisational environments with a relatively slow rate of change. The main evaluation activity is goal-monitoring and efficiency, or costs to achieve output goals.
- **Radical and Well defined**
  Methods categorised in this group are characterised as useful in evaluating radical IT investments where the cause and effect relationship is unclear but the goals are clear (in other words consensus is established in the organisation).
- **Conservative and Fuzzy**
  The third group methods is characterised as useful in establishing consensus in the organisation. The methods are not necessarily providing a financial output and are more focused on the process of evaluation rather than the result.
- **Radical and Fuzzy**
  Methods in this category use a variety of criteria but the main criterion is qualitative benefits. The evaluation, by using these methods, is characterised as based on inspiration rather than rational calculations. They are good at evaluating IT investments in undefined situations like: unclear goals, technical impact, turbulent and complex environment and little consensus in the organisation.

The four groups cover a wide range of methods by describing the conditions they are good at evaluating. A few problems are, however, related to this categorisation as described in the following. Based on the description of the four groups (seen above) it can be difficult to identify where to categorise each method, primarily because of the groups' imprecise definitions. Categorising the methods would therefore be based on the categoriser's perception of the methods and the four defined groups. Another problem (which is related to the first) is that the categorisation of the methods is revealing only a little information about the methods themselves (like evaluation criteria used).

Another categorisation is proposed by (Renkema & Berghout 1997). They divide the methods into four groups depending on the methods' predominant approaches. The four approaches are described below:

- **The financial approach**
  These methods are traditionally prescribed for evaluation and selection of all kinds of corporate investments. Basically they focus on the financial criterion of investments by analysing the investment's cash in and outflow.
- **The multi-criteria approach**
  Methods categorised in this group are not only focusing on the investment's financial impact but also include other evaluation criteria, like strategic match, that are not necessarily easily expressed in monetary terms. They are evaluating the IT investment by using several criteria, which can be combined into single measure (however, not all multi-criteria methods do this).
- **The ratio approach**
  This approach characterises methods that use ratios to express organisational effectiveness. Examples of such ratios are IT expenditures against total turnover and all yields that can be attributed to IT investments against total profits. They do not necessarily take only financial figures into account.
- **The portfolio approach**
  The last group of methods are characterised as project portfolios that evaluate IT investments by plotting them against several evaluation criteria. The used criteria can be chosen from a variety of criteria like financial, strategic, technology etc.

The four defined approaches are, contrary to the previously described categorisation, more exactly defined which makes the categorisation of the methods easier. Furthermore it represents a variety of methods with a relatively clear distinction. However, distinguishing the methods based on their predominant approach is good but it also implies that a group like *The ratio approach* is limited in its use, both because few methods are actually categorised in this group, and because this approach is rather simple which makes the methods less useful (this is, however, not valid for all the methods categorised in this group).

On the basis of the different ways of categorising the methods, as described above, plus the comments given, a new way of categorising the methods is proposed. The developed categorisation is not thought as the ultimate categorisation beyond which others become obsolete (as this is by definition not possible), but as a categorisation that is useful to get an overview of the existing methods and which represents the wide variety of available methods.

In the proposed categorisation, the type of output distinguishes the groups of methods. This is not significantly different from (Renkema & Berghout 1997)'s way of categorising the methods, but where their differentiation criterion is the predominant approach used, which means that a number of categories are weaker than the rest, it is the actual type of output, which is a simple way of categorising and enables a more equal distribution of methods within each category.

Three groups of methods are therefore defined based on their predominant type of output:

- **The Financial methods**
  Methods, that have an output of a financial character or which are expressing a financial condition, are categorised in this group. They are assessing IT investments' financial value

by analysing its cash in- and outflow and may assign arbitrary monetary values to non economically measurable costs and benefits.

- **The Quantitative methods**
  The methods categorised in this group are providing an output with one or several non-financial and quantitative measures when evaluating the IT investment. This implies that the evaluation is completed by using, not only a financial criterion, but also non-financial criteria. In case of methods using multiple criteria they may combine the measures into one single quantitative output, or each of the measures may be quantitatively expressing one of the criteria used.
- **The Qualitative methods**
  The last group of methods is categorised as evaluating IT investments by providing qualitative output (e.g. portfolio diagrams and subjective statements) which, by definition, are not quantitative. The methods are not in themselves focused on providing a financial output even though they might be a part of the completion of the method.

The three groups of methods are separate and the main characteristic distinguishing the groups is simple which, in combination, makes it easy to categorise the methods into one of the groups. The categorisation is simple although not as simple as the two firstly described categorisations. The developed categorisation is used on the methods listed in *Table 2* and can be seen in *Table 4*.

*Table 4. Categorisation of IT evaluation methods*

| The Financial methods | The Quantitative methods | The Qualitative methods |
|---|---|---|
| Accounting Rate of Return (ARR) | Analytic hierarchy process | Bedell's method |
| Application transfer team approach | Application benchmark technique | Benefits-risk portfolio |
| Breakeven analysis | Automatic value points | Benefit assessment grid |
| Boundary values (BV) | Balanced scorecard | Buss's method |
| Business Impact or Time Release Analysis | Bayesian analysis | Composite and ad hoc methods |
| Cost Avoidance | Bradford Information System Evaluation | Critical Success Factors (CSF) |
| Cost Benefit Analysis (CBA) | Method (BISEM) | Customers resource life cycle |
| Cost Benefit Ratio | Information Economics (IE) | Functional Analysis of Office |
| Cost displacement | Information Systems Investment Strategies | Requirements |
| Cost effectiveness analysis | (ISIS) | Game-playing and role-playing |
| Cost-value technique | A Health Check of the Strategic | Investment mapping |
| Cost-revenue analysis | Exploitation of IT | Investment portfolio |
| Decision Analysis | Knowledge based systems for IS evaluation | Potential Problem Analysis (PPA) |
| Delphi evidence | Kobler Unit framework | Process Quality Management (PQM) |
| Economic Assessment – I/O Analysis | Measuring the Benefits of IT Innovation | Proportion of Management Vision |
| Executive Planning for Data Processing | (MBITI) | Achieved |
| (EPDP) | Multi Objective Multi Criteria (MOMC) | Prototyping |
| Hedonic wage model | Option theory | Simulation |
| Internal Rate of Return (IRR) | Quality engineering | Socio-technical project selection |
| Lautanala's method | Satisfaction and priority survey | Strategic Application Search (SAS) |
| Net Present Value (NPV) | Strategic Investment Evaluation and | Strategic option generator |
| Payback period | Selection Tool Amsterdam (SIESTA) | System dynamics methodology |
| Profitability index method (PIM) | Seven milestone approach | Systems Investment Methodology (SIM) |
| Relative Competitive Performance | Strategic Match Analysis and Evaluation | Value Chain Assessment |
| Return On Investment (ROI) | Systems measurement | User Attitudes |
| Return on Management (ROM) | User Information Satisfaction (UIS) | Ward's portfolio analysis |
| Requirements-costing technique | User utility function assessment technique | Work Study Assessment |
| SESAME | Value Analysis (VA) | |
| Structural models | | |
| Time savings times salary | | |
| Transformate Model | | |
| Zero based budgeting | | |

The three methods listed in *Table 2*, which have been assigned an asterisk, cannot be categorised because of the lack of literature and are therefore not included in *Table 4*.

All three groups have a high number of methods which is a strength compared to the other possible categorisations as described above. Viewing the table it is surprising how many qualitative methods there are but this is mainly because of the many management and portfolio methods which are included in this group.

## 2.5 Summary

During this chapter a description of the history of IT evaluation is briefly presented in relation to the general evolution of IT. An interesting tendency is the shifting views on IT, which over time have gone from primarily experimental use to viewing IT as a capital investment that is only one out of the many possible, and which has significantly affected the development of the companies' IT evaluation practice.

82 IT evaluation methods have been identified and listed. Each of these methods can be described by a number of parameters that have been identified through a literature review.

A number of parameters have been identified as relevant when taking the context of the IT evaluation into consideration.

- Decision process
- Relation of project to business
- Leadership role
- Industry situation
- Company size

A number of parameters have, furthermore, been identified as relevant to the methods.

- Extent of involvement
- Stage of IT evaluation
- Type of impact
- Cost of method
- Evaluation criteria
- Type of IT investment
- Scope of IT evaluation method
- Difficulty of IT evaluation method
- Type of outcome

These 9 parameters can be used to describe the methods' similarities and differences and they can therefore also be used to identify the best matching method if the requirements for the method are identified.

Lastly a new way of categorising the methods is proposed based on the type of output provided by the method. This leads to the definition of three different groups of methods.

- The financial methods
- The quantitative methods
- The qualitative methods

Based on these three groups the methods listed in *Table 2* are categorised and the result of this can be seen in *Table 4*.

# Chapter 3: Four IT evaluation methods

In this chapter four IT evaluation methods are chosen from the list in chapter 2. These will, in later chapters, be used both as a basis for the completion of the case studies and for the framework.

Firstly, the choice of methods is argued and commented on and secondly, each the four methods is described with regard to: (a) their structure and approach (b) their characteristics by using some of the parameters identified in chapter 2, (c) their strengths and weaknesses from a theoretical point of view and (d) the process of how to complete the methods. The detailed description of the four methods is valuable for the understanding of the rest of the thesis, as the methods will be assumed to be known in the case studies and the framework.

## 3.1 The choice of four IT evaluation methods

Four IT evaluation methods were chosen and a more detailed analysis of these was completed. The four methods are, in chapter 6, tested in a series of case studies in relation to companies from the construction industry and, in chapter 11, used as a basis for the framework. Only four methods were chosen primarily because of time limitation and because testing all the available methods was simply not possible as new methods are developed and published almost every day (choosing all the available methods would indeed be a time-consuming task).

Based on the developed categorisation of the methods as proposed in chapter 2, at least one method is chosen from each of the three defined groups. This is because they will then represent a larger group of methods and therefore both the completed case studies and the framework will be based on four representative methods.

The three chosen methods are the following (the names written in Italic show how they are categorised):

- Net Present Value (NPV) *The Financial methods*
- Information Economics (IE) *The Quantitative methods*
- Critical Success Factors (CSF) *The Qualitative methods*

The three methods are chosen on the basis of the following criteria, (a) the chosen method should represent the characteristics of the available methods in the group, (b) the methods should be well-documented and accessible for further analysis, (c) the methods should be well structured and (d) the methods should often be cited in literature. The three listed methods are all fulfilling the criteria listed.

The fourth method is chosen to be:

- Measuring the Benefits of IT Innovation (MBITI) *The Quantitative methods*

This method is not chosen on the basis of which category it belongs to, but more because it is the only method of those listed in *Table 2* that are developed especially for evaluation of IT investments in companies from the construction industry (this is not entirely true because Lautanala's method is also developed especially for the construction, but as published it was used on an industry level rather than a company level).

## 3.2 Analysis of the four IT evaluation methods

A brief introduction to each of the four methods is given in this section so it enables the reader of this thesis to understand the methods' origins, their basic approach and the type of output.

### 3.2.1 Net Present Value

NPV is a financially oriented method that is widely used to evaluate capital investments. A survey completed by (Carsberg & Hope 1976) showed that NPV was the fourth most used decision-making technique (exceeded by Qualitative judgements, Internal Rate of Return and Payback period). NPV uses a Discounted Cash Flow (DCF) technique that allows the evaluator to take account of the interest rate. The theoretical basis of this method was developed by an American economist, Irving Fisher (1867-1947), who described the equation of exchange upon which much of the classical and monetarist theory of inflation is based (Brealey & Myers 1988).

Many textbooks on the topics of financial management and capital investment analysis provide an introduction to the evaluation method. It is not an evaluation method that was originally developed for evaluation of IT investments, but can be applied to all capital investment. R. A. Brealey and S. C. Meyers describe the evaluation method in their book called "Principles of Corporate Finance" (Brealey & Myers 1988). Other references describing the method are (Atrill & McLaney 1997;Ballantine & Stray 1998).

The following equation is used to calculate NPV's output:

$NPV_n = \sum_{j=0}^{n} \frac{F_j}{(1+i)^j}$ , n = lifetime of investment, $F_j$ = net cash flow in year j, i = rate of interest

Briefly described, the equation calculates the net present value of each year's net cash flow and summarises these for the lifetime of the IT investment. Put another way the output of NPV is an economic measure that shows what the return of the investment is when the costs are subtracted from the benefits, and each year's resulting cash flow is discounted to the present value.

A more detailed description of the method can be found in (Brealey & Myers 1988).

### 3.2.2 Measuring the benefits of IT Innovation

MBITI was developed by Construct IT, UK and published in 1998 (Construct IT 1998). It is the only one of the four methods that is specifically developed for use by companies from the construction industry. The method is new compared to the other methods, but has been tested with satisfying results on some UK companies from the construction industry (Carter, Thorpe, & Baldwin 1999).

This method is called a framework because it provides the evaluator with a structure in which the evaluator has to provide the data needed to answer the questions and fill out the tables. In this thesis MBITI is referred to as an IT evaluation method and not a framework.

The method is divided into two main parts: a strategic part and a benefit part. The strategic part is composed of seven questions about the background and the strategic aspects of the IT investment (see for example Appendix B7). The benefit part consists of three tables focusing on: the efficiency benefits (the economically measurable benefits), the effectiveness benefits (the other measurable benefits) and the performance benefits (non-measurable benefits). Each of the tables is divided into

10 general business processes that have been defined so they can be applied to a company from the construction industry (the rows seen in *Figure 6*):

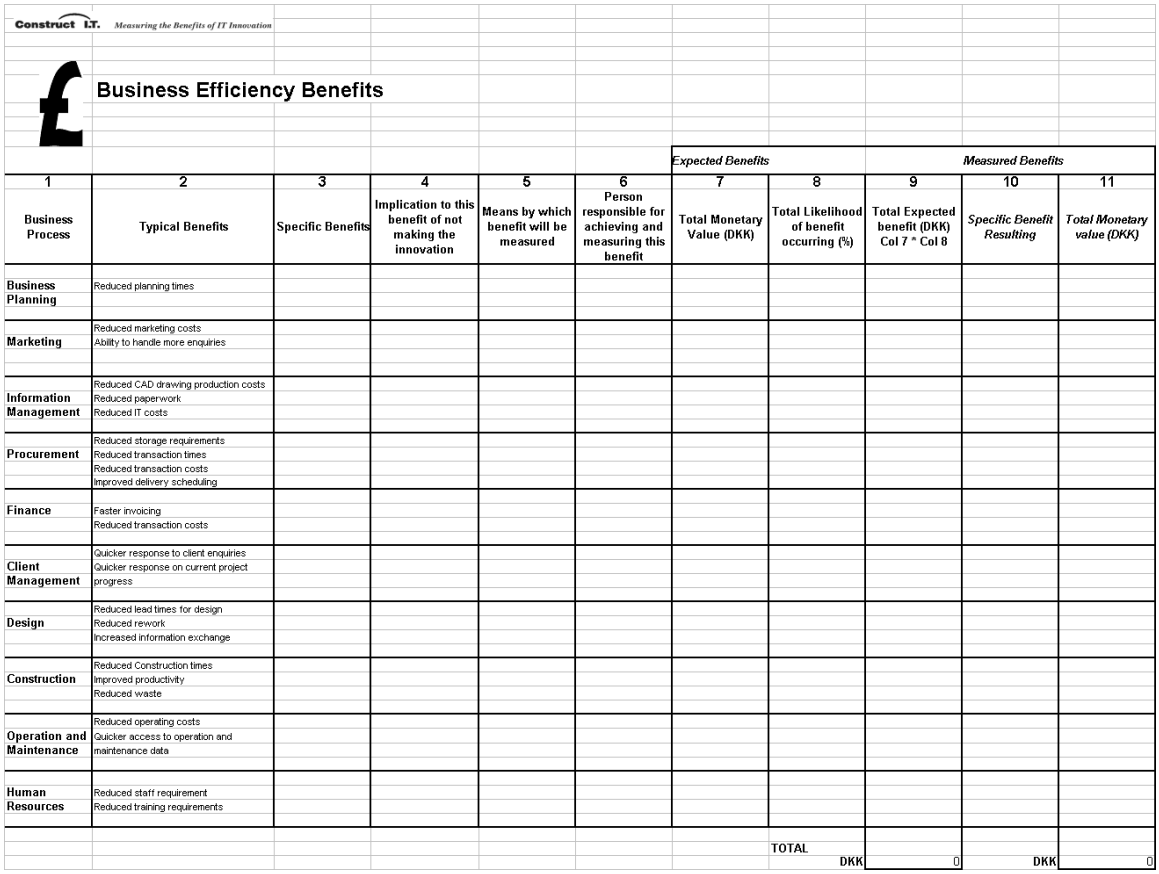
- Business planning
- Marketing
- Information management
- Procurement
- Finance
- Client management
- Design
- Construction
- Operation & Maintenance
- Human resources

The 10 business processes are defined in order to help IT evaluation champion(s) with identifying the benefits that can be associated with the IT investment. It does, however, not mean that they have to identify at least one benefit for each of the 10 business processes.

*Table 5. The content of MBITI's three tables*

| Efficiency table | Effectiveness table | Performance table |
|---|---|---|
| Typical benefits | Typical benefits | Typical benefits |
| Specific benefits | Specific benefits | Specific benefits |
| Implication to benefit of not completing the IT investment | Implication to benefit of not completing the IT investment | Implication to benefit of not completing the IT investment |
| Measurement unit | Measurement unit | Measurement unit |
| Responsible person | Responsible person | Responsible person |
| Estimated value of benefit | | |
| Likelihood of benefit occurring | Likelihood of benefit occurring | Likelihood of benefit occurring |
| | Total weighting of benefit | |
| Total estimated benefit | Total estimated benefit | |
| | | Qualitative rating and description of the impact of the expected benefit |
| Specific benefit resulting | Specific benefit resulting | Specific benefit resulting |
| Total measured value | Total measured value | |
| | | Qualitative rating and description of the impact of the measured benefit |

The three tables are not completely alike but they are generally structured the same way. An example of the efficiency table is shown in *Figure 6*.



Construct I.T. *Measuring the Benefits of IT Innovation*

**Business Efficiency Benefits**

| | | | | | | *Expected Benefits* | | *Measured Benefits* | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| Business Process | Typical Benefits | Specific Benefits | Implication to this benefit of not making the innovation | Means by which benefit will be measured | Person responsible for achieving and measuring this benefit | Total Monetary Value (DKK) | Total Likelihood of benefit occurring (%) | Total Expected benefit (DKK) Col 7 * Col 8 | *Specific Benefit Resulting* | *Total Monetary value (DKK)* |
| Business Planning | Reduced planning times | | | | | | | | | |
| Marketing | Reduced marketing costs<br>Ability to handle more enquiries | | | | | | | | | |
| Information Management | Reduced CAD drawing production costs<br>Reduced paperwork<br>Reduced IT costs | | | | | | | | | |
| Procurement | Reduced storage requirements<br>Reduced transaction times<br>Reduced transaction costs<br>Improved delivery scheduling | | | | | | | | | |
| Finance | Faster invoicing<br>Reduced transaction costs | | | | | | | | | |
| Client Management | Quicker response to client enquiries<br>Quicker response on current project progress | | | | | | | | | |
| Design | Reduced lead times for design<br>Reduced rework<br>Increased information exchange | | | | | | | | | |
| Construction | Reduced Construction times<br>Improved productivity<br>Reduced waste | | | | | | | | | |
| Operation and Maintenance | Reduced operating costs<br>Quicker access to operation and maintenance data | | | | | | | | | |
| Human Resources | Reduced staff requirement<br>Reduced training requirements | | | | | | | | | |
| | | | | | | | TOTAL DKK | 0 | DKK | 0 |

*Figure 6. Example of the Efficiency table from MBITI*

MBITI's output are divided into three areas (each reflecting one of the three tables). The output are basically a summary of the content in the three tables. The first output illustrates an estimate of the cost savings of the IT investment and the second output is displaying the relative increase of the effectiveness benefits. The third and last output is displaying the non-measurable benefits' significance.

*Table 6. Example of output table from MBITI*

| Type of Benefits | Expected Benefits | Measured Benefits |
|---|---|---|
| Efficiency Benefits - Quantifiable and Financial | Total forecast monetary value | Total realised monetary Value |
| Effectiveness Benefits - Quantifiable but Non-Financial | Total forecast score / 100 | Total realised score /100 |
| Business Performance Benefits - Non-Quantifiable and Non-Financial | | |

The two columns in the table are focused on the estimated benefits and the measured benefits. Entering the data from an IT evaluation into the output table enables an easy comparison of the expected benefits and the measured benefits. This comparison will potentially reveal some

interesting differences that can be used as guidelines for how to examine the estimates or the measured benefits.

Further information about MBITI can be found in (Construct IT 1998).

### 3.2.3 Information Economics

The IT evaluation method called, *Information Economics*, was developed by Marilyn M. Parker (IBM) and Robert J. Benson (Washington University) with some help from H. E Trainor (AMTRAK) and was first published in 1988 in the book of the same name (see (Parker & Benson 1988)).

IE is the structure for evaluating alternatives for IT investments in a company. It consists of costs and values, tools and measurements. They are coupled with risk evaluation and other investment issues in a consensus-building, decision-making process. It furthermore addresses investment decisions concerning specific application projects and information systems architectures.

The method is basically divided into three parts: the economic domain, the business domain and the technology domain.

Several areas and factors have been defined in IE and these are illustrated in *Figure 7*.

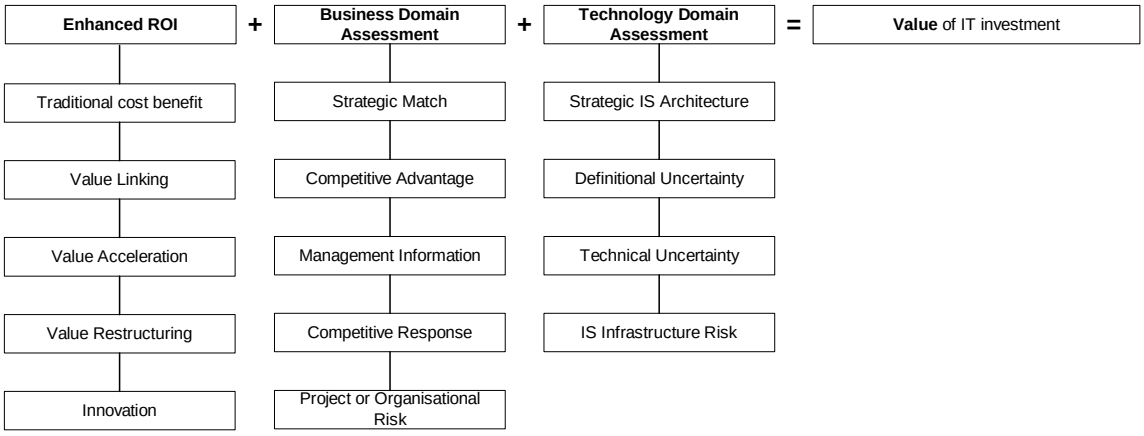



*Figure 7. The three domains in IE*

Each of the areas and factors are described.

The **Economic domain (+)** is divided into five areas.

- **The traditional cost/benefit analysis**
  This area focuses on the directly quantifiable costs and benefits of the IT investment such as software cost, reduction of operating expenses, etc.
- **Value linking (VL)**
  In this area all economically quantifiable benefits that are achievable in other business units of the company because of the IT investment usage, are included.
- **Value acceleration (VA)**
  Quantifiable economic benefits, that are characterised as one-off benefits e.g. reduced time scale for operations, belong to this area.
- **Value restructuring (VR)**
  Benefits that can be characterised as increasing the employees' time spent on more value-

adding activities because of the IT investment (improved job productivity), are in focus in this area.

- **Innovation (IN)**
  This last economic area focuses on the benefits achieved when IT investments provide innovating aspects like new business markets or competitive advantages to the company.

By defining three different types of IT application it is possible to identify which of the economic domain factors are relevant to complete. *Figure 8* shows which factors in the economic domain are relevant in which types of IT application. The following definitions of the three different IT applications are used (descriptions are taken from (Parker & Benson 1988) p. 103):

- **Substitutive**
  Substitutive applications are those that substitute machine power for people power. Examples are payroll, accounting, and billing applications (all these use a bottom-up approach meaning that the IT investments replace and/or support manual working procedures).
- **Complementary**
  Complementary applications focus on increasing the productivity and employee effectiveness for existing activities. Examples of the latter are spreadsheets, graphics and query packages. An example of an alignment application is word processing for an administrative (overhead) function. An impact example (top-down) is a marketing network and terminals for order entry or query by customers in their offices.
- **Innovative**
  Innovative applications are those designed to sustain or gain competitive edge. Examples include home banking and expert financial systems. Examples of impact (changing the business) include creating a new market and creating differentiation through cost reduction.

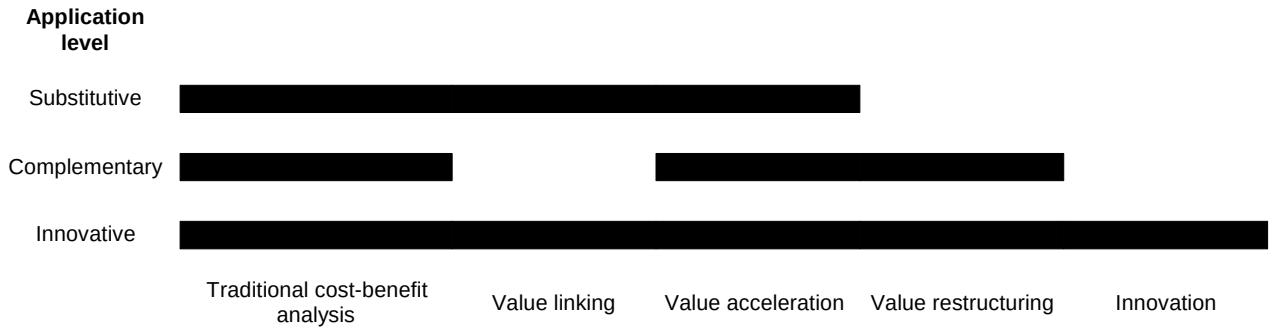



*Figure 8. Choosing the economic areas in IE*

The areas of the economic domain that are needed to be included in the ROI factor calculation can be determined from Figure 8. By identifying the categorisation of the IT investment in one of the three applications defined earlier, it can be derived from the figure which of the five areas should be included in the economic domain.

Two types of factors are defined (see eventually the following); Value factors (indicated by +) and Risk factors (indicated by -). Value factors are per definition adding a positive value to the IT investment whereas Risk factors are indicating an increased risk for failure for the IT investment.

The business domain consists of 5 factors:

- **Strategic match (SM) (+)**
  How well does the IT investment support the strategic plans in the company? The degree of match between the strategic plans and the IT investment is the focus of this factor.
- **Competitive advantage (CA) (+)**
  Implementing the IT investment will provide some competitive advantage to the company. This factor focuses on how significant is the competitive advantage the company achieves by implementing the IT investment.
- **Management information (MI) (+)**
  This factor focuses on providing information to the company's managers and on the degree of information support to the managers that is enabled by the IT investment.
- **Competitive response (CR) (+)**
  How long is it possible to delay the IT investment without significant reduction of competitive strengths? The factor focuses on how important the IT investment is to the company's position in its business area.
- **Project and organisational risk (OR) (-)**
  How large is the organisational risk for failure if the IT investment is implemented? It focuses on the degree to which the organisation is capable of carrying out the changes required by the IT investment.

The technology domain consists of 4 factors:

- **Strategic IS architecture (SA) (+)**
  How well does the IT investment fit into the existing IS architecture plans? This factor evaluates the degree to which the project is aligned with the overall information systems strategies.
- **Definitional uncertainty (DU) (-)**
  This factor assesses the degree to which the requirement and/or the specification of the IT investment are known.
- **Technology uncertainty (TU) (-)**
  How well technically prepared is the company in order to use the IT investment? This factor assessed the readiness of the technology used in the IT investment.
- **IS infrastructure risk (IR) (-)**
  This factor focuses on a risk assessment of the degree of non-project investment necessary to accommodate the IT investment.

The economic domain is assigned a mark (ranging from 0 to 5) based on the calculation of Return On Investment (ROI) using the five areas mentioned above. Each of the factors described in the business and technology domain is assigned a mark based upon an individual scale description ranging from 0 to 5.

A weight of each of the marked factors is identified using a company perspective (not from the IT investment perspective which is done through the marking of the factors) based on a scale ranging from 0 to 5. The weights allow companies to prioritise which factors are more important than the others by assigning these a higher weighting.

Two numerical output are the result of completing IE. The first shows the total value of the IT investment and is calculated on the basis of the positive factors mark multiplied by the company's weighting of that factor. The total value illustrates the value (with regard to economy, strategy and technology) of implementing the IT investment to the company. The total value can range from a minimum of 0 to a maximum of 150 (it is, by IE's authors, suggested that it is normalized so the

interval ranges from 0 to 100). The second output is the total risk. It is calculated the same way as the total value but using the risk (negative) factors instead of the positive factors. The total risk illustrates the risk of failure of implementing the IT investment. It can range between 0 and 100.

| | ROI | SM | CA | MI | CR | OR | SA | DU | TU | IR |
|---|---|---|---|---|---|---|---|---|---|---|
| factor | + | + | + | + | + | - | + | - | - | - |
| **Business Domain** | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| **Technology Domain** | | | | | | | 0 | 0 | 0 | 0 |
| Weight distribution | | | | | | | | | | |
| Sum | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Total Value** | **0** | out of | max. | 150 | and | min. | 0 | | | |
| **Total Risk** | **0** | out of | max. | 100 | and | min. | 0 | | | |

*Figure 9. Summary sheet from IE*

The summary sheet from IE can be seen in *Figure 9*. The ten factors that (depending on whether it is a positive or negative factor) have an influence on the estimated total value and total risk are listed by their abbreviations in the top of the figure. Another important aspect in the figure is the third row of cells that contains the company weightings of the factors.

For a more detailed description of the IE read (Parker & Benson 1988).

### 3.2.4 Critical Success Factors

Originally the method Critical Success Factors was developed by J. F. Rockart and it was published in the paper “Chief executives define their own data needs” in 1979 (Rockart 1979). Much has been written about the evaluation method and several improvements have been suggested by a variety of authors (Bergeron & Bégin 1989;Butler & Fitzgerald 1999;Hochstrasser & Griffiths 1991;Teo & Ang 1999;Williams & Ramaprasad 1996).

The original idea of CSF was to help business executives with identifying the key requirements that must be fulfilled to ensure success for a manager or a company. By changing the scope a little bit the evaluation method can be used to identify the key requirements to ensure success for an IT investment. It is for this purpose that the evaluation method is used within the case study. Hochstrasser and Griffiths have implemented some improvements to the method in their book “Controlling IT Investment - Strategy and Management” so the evaluation method can be used to evaluate IT investments (Hochstrasser & Griffiths 1991).

Critical success factors are key areas of broader organisational concerns that have an influence on the success of an IT investment. If the critical success factors are not achieved they will become the major obstacles to further corporate progress and ultimately result in a loss of business.

Three major tasks have to be completed when the method is used:

- Identifying the set of top-level corporate goals by management with regard to the IT investment.
- Isolating the detailed tasks, processes, and resources needed to optimally achieve the set of goals.
- Derive a high-level specification of the general tasks required to enable the detailed activities to be performed effectively.

The major tasks described above are completed through a series of interviews with business managers and end-users of the IT investment. In the interviews a number of questions are answered with the purpose of identifying the critical success factors for the IT investment.

The output of CSF is a list of ranked critical success factors for implementing the IT investment. The output is very subjective in nature but represents the stakeholders' view of the IT investment.

A detailed description of CSF can be found in (Rockart 1979).

## 3.3 Characteristics

The four methods are described with regard to the parameters identified and listed in chapter 2. The parameters have been rearranged so their sequence is more logical.

*Table 7. Characteristics of the four IT evaluation methods*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| Type of IT investment[8] | Automation<br>Direct value added | Mandatory<br>Automation<br>Direct value added<br>MIS and DSS systems<br>Infrastructure | Mandatory<br>MIS and DSS systems<br>Infrastructure<br>Strategic systems<br>Business transformation | Mandatory<br>Infrastructure<br>Inter-organisational<br>Strategic systems<br>Business transformation |
| Type of impact | Financial | Financial<br>Quantitative<br>Qualitative | Financial<br>Quantitative<br>Qualitative | Qualitative |
| Evaluation criteria | Financial | Financial<br>Strategic<br>Effectiveness of use<br>Risk | Financial<br>Strategic<br>Competitive<br>Technology<br>Risk | Requirements<br>(End user-satisfaction) |
| Stage of IT evaluation | Ex-ante | Ex-ante<br>Ex-post | Ex-ante | Ex-ante |
| Type of outcome | Financial | Financial<br>Quantitative<br>Qualitative | Quantitative | Qualitative |
| Difficulty of IT evaluation method | Low | Medium | High | Low |
| Cost of methods | Low | Medium | High | Low (Medium) |
| Extent of involvement | Low | Low (medium) | Medium | High |
| Scope of IT evaluation method | All levels | Department<br>Company<br>Building project | Department<br>Company | All levels |

Viewing the characteristics of the four methods reveals that the methods represent a wide range of differences. The characteristics of the methods are, in the following, described and compared with each other.

Both MBITI and IE are able to evaluate IT investments where several types of impact are relevant. NPV and CSF are, in comparison, only able to evaluate one type of impact respective, Financial and

[8] The parameter, *Type of IT investment*, is based on (Farbey, Land, & Targett 1993)'s categorisation of different IT investments

Qualitative. This characteristic is highly related to which types of IT investment the methods are able to evaluate and need to be addressed in the framework.

The subjectivity of the methods is highest for NPV because it only uses financial measures. NPV should, however not, because of this, be regarded as providing a fully objective output as the output is often based on estimates of the costs and benefits directly associated with the IT investment which, by definition, is subjective. For MBITI and IE the subjectivity is neither high nor low because they use both quantitative and qualitative measures. Only CSF uses qualitative measures in its evaluation and has a low subjectivity.

The criterion used in the evaluation is the characteristic in which the methods differ most from each other. NPV is naturally using a financial criterion (but as the only criterion) which MBITI and IE also use but they have a wider range of evaluation criteria. MBITI is using criteria which can be used in both ex-ante and ex-post evaluations whereas IE uses criteria that cover a broader range of aspects of the IT investment. CSF primarily uses a requirement criterion but may also be used to evaluate the end-user satisfaction (in this case end-user expectations).

All the methods can be used in ex-ante evaluations whereas only MBITI is useful in ex-post evaluations because this has been integrated into the method.

The type of output provided by the method is for most of the methods related to the IT evaluation criteria used. This is valid for NPV that has a financial output. MBITI also has a financial output but has furthermore both a quantitative and qualitative output (corresponding to the three tables in the method). As IE calculates two quantitative measures (Total value and Total risk) it has a quantitative output. Lastly, CSF has a qualitative output.

The most complex, and therefore difficult, method is IE as it requires involvement from many persons (among others the board of directors, who need to determine the weighting of the factors). MBITI is also a complex and difficult method even though not as much as IE. In comparison both NPV and CSF is considered as simple and therefore easy to use.

The difficulty of the method is closely related to the cost of completing it and therefore these characteristics have a cost almost similar to that identified under difficulty of method. One exception is CSF as it requires some time from each of the interviewed stakeholders (in comparison NPV can almost be completed by one person). If many stakeholders are included in the completion of the method then the cost would be defined as medium.

CSF is without doubt the method requiring the greatest involvement from the stakeholders and thus the highest extent of involvement because several of the IT investment's stakeholders are involved. IE is likewise requiring a significant degree of involvement as at least one manager, one IT person and the board of directors, are providing input. The involvement required is, however, smaller than for CSF. Both NPV and MBITI require a low extent of involvement (as it can be completed by one person) but completing the measurement part of MBITI requires a higher level of involvement.

All the methods are useful to evaluate IT investment on a company and department level, but only NPV and CSF can be used on all levels. This is primarily because of these methods' simple structure. MBITI is, beside its usability on a company and department level, also usable in evaluating IT investment in building projects.

## 3.4 Theoretical strengths and weaknesses of the methods

None of the methods are perfect in all possible IT evaluations and therefore the methods' theoretical strengths and weaknesses need to be analysed in order to achieve a better understanding. This will, in a later chapter, be combined with the difficulties experienced in completing the methods in the case studies.

### 3.4.1 NPV

The theoretical strengths of NPV can be divided up into two groups: Economic strengths and usage strengths.

*Economic strengths:*
Using NPV requires forecasting of the actual cash flow of an investment. This is an advantage because the data used to calculate the output is the "realised" result and not the result from an accountant's point of view (accountants use concepts like depreciation). The output of NPV will therefore show the actual value of the investment rather than its accounting value.

Another related strength of NPV is that the output shows the actual profit from completing the investment. This enables the evaluator to directly compare different investment proposals on the basis of the output. Some financial methods (e.g. IRR) calculate a rate or ratio which then expresses the value of the investment. A rate or ratio is a relative measure and, if used to compare different investment proposals, it might result in a bad decision because the scale of the investments is not taken into consideration.

NPV is the only of the four methods that recognises the following statement: a DKK today is worth more than a DKK tomorrow (this is true statement as a DKK invested today can start earning interest immediately). Other financial methods (like payback period and ARR) do not consider this issue and might lead to different conclusions if certain conditions are valid (e.g. in untraditional cash flows).

NPV also considers the opportunity costs of money[9] which other methods (e.g. ARR) does not consider. This allows the evaluator to consider what return the invested money could accrue by, for example, putting the money in the bank. By determining the rate of interest at which the cash flows are discounted to present value, the evaluator can consider the opportunity cost of money.

*Usage strengths:*
NPV is useful when evaluating investments where it is expected they will deliver direct savings or directly attributable revenue benefits. Investments where the main impact is financially measurable are, when using NPV, evaluated with respect to this impact. Therefore using NPV on these investments will provide a good insight into the investment's financial costs and benefits. This is also valid for investments that have a low uncertainty regarding the outcomes.

In cases where several investments are competing for funding, and there is a need for comparing the potential outcome of the different investments by using a financial approach, NPV is a suitable method. The output from NPV for different investments are directly comparable with each other as long as the rate of interest has been determined properly.

[9] The opportunity costs of money is the earnings that could be achieved by investing them elsewhere (e.g. a bank)

*Weaknesses:*
Some of the weaknesses in NPV can be derived from the limitations mentioned in the method's strengths. First, for investments where the benefits cannot be precisely estimated using cash flow terms, NPV would not be able include these costs and benefits in the output and thus the output would not reflect the true impact of the investment. Secondly, in investments where there are considerable uncertainties regarding the value of the estimates, an imprecise output would be achieved which may be of little use.

Using NPV when comparing different investments has to be done with some caution, as it would give an unbalanced comparison if the timescales of the compared investments differ significantly. If an investment is generating an output just as high as another investment, but in twice the time, then the latter investment should be chosen, but they would be ranked equal by using NPV.

NPV is meant to be used in ex-ante evaluations, but may also be used in ex-post evaluations. The method is, however, not designed for this purpose and some considerations and preparations need to be made if NPV is used in ex-post evaluations. For example when identifying the measurable costs and benefits the evaluator should also consider how to measure them (this is not a necessary step in ex-ante evaluations).

The method is not designed for IT evaluations and this may arguably be a weakness of the method. The strength in this is that the method can be used in many different types of investment for comparison between them, so the company can choose the best (in financial terms) investments which are not necessarily IT investments. The primary reason considered as a weakness of the method is that IT investments are, in some aspects, significantly different to other investments (see eventually (Powell 1999) with which NPV is not able to cope (e.g. intangible benefits).

**Measuring the Benefits of IT Innovation**
*Strengths:*
One strength of MBITI is that it includes three different kinds of benefits, which give a good overview of the investment's impact on the affected domain (often the company). The three types of benefit have been defined so it is very easy to identify where a benefit should be categorised. The approach is almost similar to cost and benefit analysis but it does differ significantly in one aspect. Where CBA assigns arbitrary values to intangible benefits, MBITI lets the benefits remain in their original form, meaning that financial benefits are estimated financially and qualitative benefits are estimated in a qualitative manner. MBITI does not try to assign an arbitrary value to a benefit instead it takes advantage of the benefits' nature. Not only does MBITI focus on three different types of benefit it also takes account of the benefits' likelihood of not being achieved (a measure that can be associated with risk).

Another strength is that MBITI has been designed especially for evaluating IT investment in companies from the construction industry. This is explicitly seen in the definition of the 10 business processes (see earlier in this chapter) used to identify the benefits. The business processes are defined so that both consulting engineers and contractors can use the method with advantage.

The whole method is designed so that the completion of the ex-post IT evaluation is made easier by having identified each of the relevant benefits, determining how to measure the benefit and the last two columns in each of the three tables. This is a significant strength as the foundation of the ex-post evaluation is established right from the beginning of the IT evaluation.

*Weaknesses:*
The method is only focusing on the benefits of the IT investment and not the costs. This means that decisions about an IT investment should not be made on the basis of the output from the method alone. This is not a mistake from the method designers' side but, even when this comment is taken into consideration, it is a weakness because estimating the full costs of an IT investment is also found to be a difficult task and should therefore also be included in the method. (Hochstrasser & Griffiths 1991) claim that human and organisational costs might well be four times as high as hardware/software costs and this indicates the importance of being able to identify and estimate the costs as well.

The benefits identified in the Efficiency table are estimated for the life-time of the IT investment. There are two problems associated with this approach (the two problems are, however, closely related to each other). Firstly, these benefits are not discounted back to present value (see the description of NPV) and, secondly, it is not possible to discount the benefits back to present because each year's cash flow is not estimated. This is naturally a problem when using the method to compare different IT investments' financial benefits because the IT investments' priority in certain cases is decided on the basis of a misleading output.

In the last table called Performance benefits, the likelihood is estimated for each of the benefits. These estimates are not used to calculate the effective value, as in the other two tables, and are therefore not as useful compared to the other tables. They are, however, useful when identifying the performance benefit's chance of being achieved.

**Information Economics**
*Strengths:*
Information Economics is a method that considers three important domains in an IT evaluation: the economic, the business and technology, both with regards to benefits and risk. The method's usage in several domains makes it useful to evaluate a wide range of IT investments. The method uses a range of different evaluation criteria which altogether may reflect a company's need for an IT evaluation, and using IE would, in many IT evaluations, fulfil the need.

It has several concepts for how to evaluate the economic impact (e.g. Value restructuring) of the IT investment and these represent the impacts from different types of IT investment, from the simple applications that automate clerical tasks to innovations that create new business areas. The concepts are in combination providing a good aid to estimating the financial impact from a variety of IT investments.

The factors defined, both in the business and the technology domain, represent issues that are often critical in evaluating IT investments. The issues address strategic importance, competitive value and technology risk, and are important in a complete IT evaluation. It is because of this that IE is a advanced method useful in many IT evaluations.

Weighting the method's factors according to the company's preferences is an important strength in the method that many other methods do not consider. The weightings allow the company to highlight factors with a high priority instead of viewing the evaluation criteria as equally important.

The last strength in IE, described in this section, is that there is an opportunity for amending either the definition of the existing factors or adding new factors. This allows the companies to change or develop the method so it more precisely suits the requirements defined by the company.

*Weaknesses:*
Few weaknesses in IE can actually be identified, but one them is that the method is using several evaluation criteria which have to be assessed even though the company is only interested in the economic domain of the IT investment. The method is a "*take it or leave it*" method and can, in some IT evaluations, be too advanced and complex compared to the needs of the company.

IE has the same weakness as mentioned in the discussions of the method, MBITI. It does not use a discounted cash flow to identify the present value of the IT investment. This is despite the fact that IE estimates the yearly cash flow, which means that it is possible to calculate the discounted cash flow. There is the possibility of including this aspect in the method by amending the economic domain (as mentioned above) but this has, for some unknown reason, not been done by Parker & Benson.

IE has primarily been designed to evaluate IT investments during the decision-making stages (ex-ante) and therefore its abilities in completing ex-post evaluations are very poor. This implies that other methods are needed if the company wants to complete ex-post evaluations. It is, however, difficult to find a method that is usable in ex-post evaluations, and where the output from IE and the other method can be compared. This is a severe weakness of the method, especially when considering its complexity, which makes it very difficult to find an appropriate method for the ex-post evaluation.

**Critical Success Factors**
*Strengths:*
The most evident strength of CSF is the involvement of the stakeholders in the IT investment. This involvement enables an identification of the stakeholders' opinion and requirements for the IT investment. Very few methods involve the stakeholders when evaluating the IT investment, but this is mentioned in many researchers' work as an important aspect of completing IT evaluations (Bannister & Remenyi 2000;Remenyi, Sherwood-Smith, & White 1997).

One of the very useful output from the method is that it identifies and reflects the factors the stakeholders believe are important for achieving success with the IT investment. If the method has been completed thoroughly then, ensuring that the identified factors are managed so they are satisfactory according to the stakeholders' opinion, the IT investment is considered as a success, at least in the stakeholders' opinion.

Another advantage in CSF is that the many identified factors highlight aspects (or criteria) with relation to the success of the IT investments. Other approaches evaluate the IT investment using a number of pre-identified criteria which may, in some cases, highlight aspects not considered as relevant by the stakeholders. CSF identifies the criteria that the stakeholders consider as relevant in the evaluation, which enables a more precise evaluation because the criteria used match the stakeholders' perception.

*Weaknesses:*
The primary strength of CSF is also the source of a weakness. Basing the data collection on the opinion of the stakeholders in the IT investment makes the output very subjective in nature. Stakeholders might, in extreme cases, have their own agendas or reasons as a basis for their opinions, which may not be in the company's interest to fulfil, but the method has no means for avoiding this. This makes the method vulnerable to political battles or other types of fraud which may (or may not) be of interest to the company.

The method does not address the economic impact of the IT investment, but may be mentioned as an important critical success factor by one or more of the stakeholders. The method is therefore not useful to evaluate IT investments with respect to the cause-effect relationship.

CSF is an ex-ante method, primarily because its purpose is to identify the requirements for a future IT system. The method is not useful in completing ex-post evaluations. This is not because it cannot be completed in ex-post evaluations, but more because the identified factors are of little value at this stage of the IT investment. This weakness is not considered as critical as the method is not focused on the cause-effect relationship of the IT investment.

## 3.5 Usage of the four IT evaluation methods

In the last section of this chapter a description of the steps needed to be completed for each of the four methods is presented. This is useful when completing the methods in the case studies described in chapter 6.

### 3.5.1 Net Present Value

Little literature exists on how to complete an evaluation of an investment using NPV. Many sources describing NPV are focusing on the data needed for completing the method, how to calculate net present value and the strength and weaknesses of the method. The following description is therefore based upon the logical steps of collecting the data needed.

NPV requires the completion of six stages.

1) **Identification of investment's lifetime and rate of interest.**
   In the first stage the lifetime of the investment (no. of years) and the rate of interest (i) are estimated.
2) **Identification and estimation of costs.**
   The second stage focuses on the identification of costs. Only economically measurable costs are included in the method. Two types of cost are addressed: development cost and running cost. The running costs are estimated on a yearly basis for the IT investment's lifetime.
3) **Identification of benefits.**
   This stage focuses on the identification of benefits of the IT investment. Only benefits that are economically quantifiable and measurable are in focus in this method.
4) **Estimation of benefits value.**
   The economically measurable benefits are, at this stage, estimated on a yearly basis for the IT investment's lifetime.
5) **Calculating the final estimated output.**
   On the basis of the estimated economically measurable costs and benefits and the rate of interest, the final expected output is calculated and presented by inputting the collected data into a developed spreadsheet containing the equations for the method.
6) **Presenting the final output.**
   In the last stage a final presentation of the estimated output (net present value) is completed.

In total six stages need to be completed in order to derive the output (net present value). By completing this method it is also possible to make a chart showing the cash in- and outflow which can be used to identify the trends in the IT investment's prospects.

### 3.5.2 Measuring the Benefits of IT Innovation

In the report presenting the method, a description (and a diagram) of how to use it has been included. This description has, more or less, been used in the completion of the method in the case studies. Some of the stages are, in the present dissertation, however, described in a more practically oriented manner.

Briefly described, the methods are completed using the following stages:

1) **Completion of interviews where the strategic questions were answered.**
   Three sets of questions focussing on describing the company, the IT investment and the current IT evaluation practice, are answered through interviews. Some of the answers from these interviews have been used to answer the strategic questions of the method.
2) **Identification of benefits.**
   This stage focuses on the identification of benefits of the IT investment. All possible types of benefits are identified without regard to their characteristics. However, in some cases, limitations were considered as relevant, so the identified benefits are restricted in their scope.
3) **Categorisation of the identified benefits into the three different tables according to their measurability.**
   The identified benefits are categorised into three different tables: the efficiency, the effectiveness and the performance table. For each benefit, if applicable, the implication of the benefit if the IT investment is not implemented, the measurement unit and the responsible person, are identified.
4) **Estimation of benefits value, weightings, likelihood and/or qualitative ratings.**
   Once all the identified benefits are categorised the estimate, if applicable, of value, weightings, likelihood and/or qualitative rating, is completed for each benefit.
5) **Calculating the final estimated output.**
   On the basis of the estimated numerical and qualitative data, the final expected output are calculated and presented by inputting the collected data into the respective spreadsheets provided by the method.
6) **Measuring the actual benefit realisation.**
   Through the identified benefits and their determined measurement unit, each benefit is regularly measured and registered. The frequency of measurement needs to be determined individually for each IT investment.
7) **Presenting the final output.**
   In the final stage a presentation of the estimated output and the measured output is completed. This is done by inputting the output of the three tables to a presentation sheet. Further conclusions should be derived by comparing the estimated benefits and the measured benefits.

In total, seven stages needs to be completed in MBITI. Some of the stages require more resources than others e.g. stages 4 and 6. Completing this method requires at least an evaluation in two stages of the IT investment's lifecycle; one before the IT investment is implemented and one during the on-going use.

### 3.5.3 Information Economics

The primary reference describing how to complete IE is (Parker & Benson 1988), who also happens to be the people who invented the method. The method is very structured and is basically completed by finishing the three domains: the economic domain, the business domain and the technology domain.

The following stages need to be completed using the method:

1) **Completion of traditional cost and benefit analysis.**
   The data needed to complete the cost and benefit analysis are collected in the first stage. The benefits are identified using a brainstorming technique, whereas the cost entries are pre-identified (using the template from (Parker & Benson 1988)).
2) **Identification and estimation of Value linking, Value acceleration, Value restructuring and Innovation benefits.**
   The benefits that can be characterised as belonging to the different categories are, at this stage, identified as an extension to the traditional cost/benefit analysis. The relevant estimates needed to complete the economic domain are identified. The relevance of the different areas in the economic domain is mainly determined by identifying the category to which the IT investment belongs (see eventually Figure 8). This means that not all the areas might be relevant to all IT investments.
3) **Calculating the ROI (the economic domain).**
   On the basis of the data identified and estimated in the previous two stages the return of investment (ROI) is calculated. This is done by using the layout and equations shown in (Parker & Benson 1988).
4) **Marking the business domain.**
   On the basis of the description of each factor in the business domain, and a defined scale ranging from 0 to 5, the factors in the business domain are marked.
5) **Marking the technology domain.**
   In a similar way the technology domain factors are marked also using a defined scale ranging from 0 to 5.
6) **Identifying the company's weight factors.**
   The company's weightings of the 10 factors are identified using a scale ranging from 0 to 5.
7) **Calculating and presenting the final output.**
   In this stage a final presentation of the estimated output is completed. The final presentation is based on the data collected in the earlier stages.

Especially stages 1 and 2 (the economic domain) are considered difficult to complete and they are crucial for estimating the financial impact on the company from the IT investment. In total 7 stages need to be completed in order to use IE and they are all completed ex-ante.

### 3.5.4 Critical Success Factors

CSF was first published in 1979 and since then many have used the method and have described how to complete it (Bergeron & Bégin 1989;Butler & Fitzgerald 1999;Hochstrasser & Griffiths 1991;Teo & Ang 1999;Williams & Ramaprasad 1996). Nevertheless the approach described below is very close to the original description provided by (Rockart 1979).

Briefly described, the evaluation method is completed using the following stages:

1) **Completion of stakeholder interviews.**
   In the first stage the stakeholders of the IT investment were interviewed and their view of the critical success factors was identified. Each interview was recorded on tape and a written summary was made. The summaries were sent to the interviewees for approval.
2) **Listing of critical success factors.**
   The critical success factors identified in each interview were combined into one list. Cases of more than one factor are judged alike and are combined into one.
3) **Ranking of critical success factors.**
   The last stage is focused on ranking the identified critical success factors so that the most important ones are listed first.

The method consists of three stages of which stage 1 is, without doubt, the most time-consuming. All three stages are completed together in the ex-ante evaluation.

## 3.6 Summary

In this chapter four IT evaluation methods have been selected and described in detail. The four selected methods are.

- Net Present Value (NPV)
- Measuring the benefits of IT Innovation (MBITI)
- Information Economics (IE)
- Critical Success Factors (CSF)

The four methods each represent a larger group of methods, with the exception of MBITI which is selected because of its relationship to the construction industry.

# Chapter 4: Survey of IT evaluation in the Danish construction industry

This chapter describes the current IT evaluation practice in the Danish construction industry. The description is based on a questionnaire survey completed together with a comparison with other related surveys.

The first part in the chapter focuses on the methodology used in the completion of the questionnaire survey. The characteristics of those companies that responded to the questionnaire are presented in order to analyse the types of company represented in the survey. Three main areas are presented and analysed; the companies' IT strategy, their evaluation of IT investments using a life-cycle approach and the development of the companies' IT evaluation practice.

The survey was completed because little knowledge exists about how companies from the construction industry evaluate their IT investments.

## 4.1 Methodology

The overall purpose of the survey is to establish an understanding of the current IT evaluation practice in the Danish construction industry. This is done by identifying how companies currently evaluate their IT investments.

The survey, comprising of a series of structured questions, was chosen as an appropriate data collection method in order to obtain a wide spectrum of data from a variety of companies. The survey was undertaken during spring 1999.

The principal objectives of the survey were:
- To identify the current practice of IT evaluation
- To investigate the maturity of the companies' approach in evaluating IT investments
- To identify different factors' influence on IT evaluation practice

The development of the questionnaire was primarily based upon a literature review where a number of different cross-industry surveys, in which the focus was on how companies evaluate their IT investments, were identified. Especially two surveys from Finland and England were used as inspiration when designing the questionnaire (Hallikainen, Heikkilä, & Saarinen 1997;Willcocks & Lester 1994).

The questions were formulated so they could be easily understood even though the responding company is not familiar with the research field. No attempt was made to define definitions so that the respondents were free to interpret the definitions in their normal manner.

A test of the questionnaire form was completed before it was sent out. First it was tested by a few colleagues from DTU, and later by an architect and a contractor. The comments on wording and structure were used to revise the questionnaire form.

The target audience for the survey was the IT manager within the company. The responses were optionally anonymous in order to maximise both the potential response rate and chances for obtaining meaningful answers to potentially sensitive questions. The mailing consisted of an

introductory letter, the questionnaire form and an envelope (for the submission of the questionnaire form).

The data received was treated as anonymous and no statistics-based deductions were made because of the small sample size. The data analysis is mostly presented by using charts and percentages.

## 4.2 Structure of the questionnaire form

The questionnaire is divided into three areas in order to examine the respondents' use of IT and how they evaluate their IT investments. The first area focuses on the responding companies' IT strategy by, for example, examining the level of strategic use of IT systems, and to gather data about what objectives for the IT usage they have. The second (and most intensively examined) area is about how companies evaluate their IT investments by, for example, determining the approach in their IT evaluation. The results and consequences are also investigated so the effect of conducting IT evaluations can be examined. Lastly, the development of the companies' evaluation practice is examined.

The questionnaire form contains 35 questions divided into the four areas, as mentioned above, on 7 pages (a template of the questionnaire form can be seen in Appendix A1 (translated to English)). The only incentive for the respondents was receiving a copy of the report with the analysis of the survey.

## 4.3 Characteristics of the responding companies

648 questionnaires were sent out to companies in the construction industry. Three types of company were chosen as the respondents: architect, engineer and contractor companies. The targeted companies were selected so that different types, sizes and geographical locations (restricted to Denmark) are represented in the survey. The addresses were obtained from the organisations PAR, FRI and DE (the branch organisations).

The overall response rate was about 12% and the distribution within the three groups is stated in *Table 8*. This is unfortunately not impressive, but similar response rates have been seen in other related surveys (Howard 1998a;Howard 2001). Because of the small response rate the findings cannot be taken as valid for the whole Danish construction industry. They may, however, show some tendencies for the level of IT evaluation practice today.

*Table 8. Response rate(s)*

| | Sent out | Returned | Response rate |
|---|---|---|---|
| Architects | 149 | 20 | 13,4% |
| Engineers | 253 | 41 | 16,2% |
| Contractors | 246 | 20 | 8,1% |
| **Total** | **648** | **81** | **12,5%** |

The highest response rate was obtained from the consulting engineers whereas only half as many contractors responded. This was despite the fact that a follow-up letter was sent especially to the contractors in order to remind them to respond the questionnaire.

### 4.3.1 Distribution of company sizes

The distribution of company sizes within the three groups is shown as a function of the number of office staff, which can be seen in *Figure 10*.

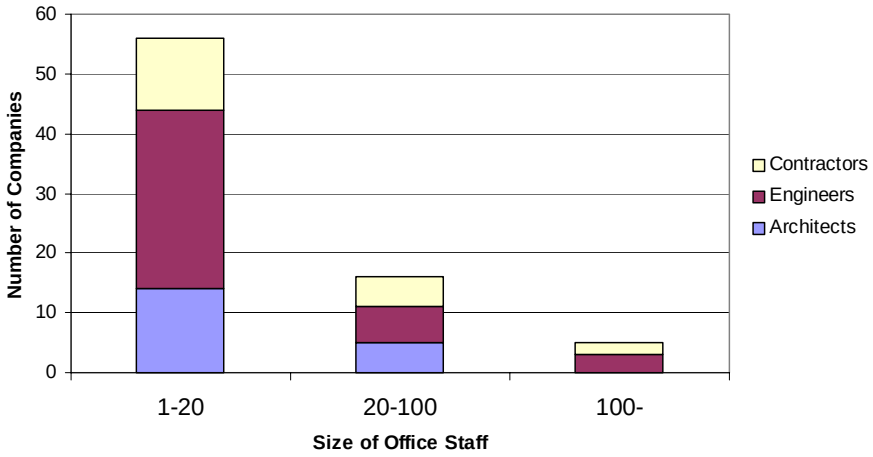



*Figure 10. Company size ( by the number of office staff)*

Two of the respondent companies are without any categories because of missing data. The biggest share of the respondents can be classified as small companies (defined as 1-20 office employees). It is worth noticing that the responding architect firms are not represented in the group of large companies (defined as 100+ office employees). The number of medium sized companies (defined as 20-100 office employees) is between the number of small and large sized companies. The unequal distribution of the companies' size is representative of the Danish construction industry.

The large number of small companies among the respondents may have influence on the findings of the survey and therefore some of the analysis will try to differentiate between the three sizes of company. The proportion of large companies compared to the proportion of small companies is significantly different and, when comparisons are made between the three groups, then the derived results or conclusions should be treated with some caution.

### 4.3.2 Investment rates in IT

The companies' spending on IT in 1997 can be seen in *Figure 11* displayed as % of company turnover.

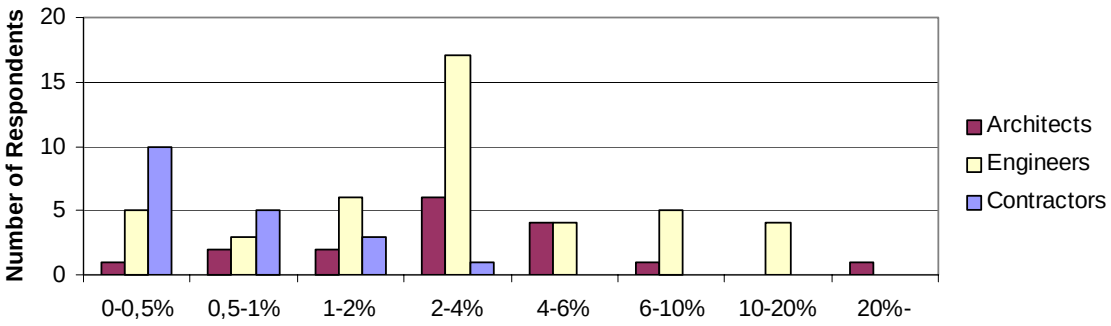



*Figure 11. Percentage of turnover spent on IT in 1997*

Two tendencies are revealed by analysing, *Figure 11*, and by comparing the three types of company. Firstly, contractors have the lowest spending rates on IT compared to consultants. Secondly, none of the respondent contractors spent more than 4% of their turnover on IT in 1997,

whereas both architects and engineers in general have a larger variety of spending rates. Most consultants spent between 2-4% of their turnover on IT. The primary reason for the difference between consultants and contractors investments rates can be explained, because contractors' turnover (which is based on the value of the building projects) is significantly larger than both architects' and engineers' (which is based on their fees). Analysing the investment rates with regard to company size, it is found that the medium-sized companies have the highest investment rate (4.2%) followed by large companies (3.2%) and small companies with the lowest investment rate (3.0%).

These results correspond with the findings in the two IT Barometer surveys, where the same tendencies can be found (Howard 1998a;Howard 2001). The IT barometer survey 2001 showed slightly higher investment rates compared to this survey and may be taken as an indication that investment rates are increasing over this period. A third survey from 1995 by (CICA & CIRIA 1995) identifies the same investment rate pattern as shown in *Figure 11*, but it also shows a generally lower investment rate for all three groups of companies (which most likely is due to the time difference in the surveys). Some cross-industrial surveys state similar findings. Price Waterhouse identified an investment rate of about 1% in the late 1980's (Hochstrasser & Griffiths 1991) and (Ballantine & Stray 1998) confirm this by identifying an average investment rate of 1% in 1992 by questioning 98 larger companies.

## 4.4 The companies' IT strategy

An IT strategy is, in this context, defined as the guidelines for the company's IT usage both with regard to goals for IT usage and how these goals should be achieved. This definition is not as exhaustive as the subject itself deserves, but serves the purpose of this dissertation well. Interested readers are recommended to read the following references (Davenport 1999;Earl 1989;Porter 1985;Walsham 1992;Ward & Griffiths 1998).

A company's IT strategy is considered as an essential part of their IT evaluation practice, mainly for the following reasons (Hochstrasser & Griffiths 1991):

- It will influence the different IT investments' desirability
- The IT evaluation will focus more easily on long-term goals rather than short-term benefits
- The IT evaluation will serve the whole company instead of individuals
- It will reduce the risk of local IT investments being incompatible with the future plans of the company

It is argued that identifying companies' current IT evaluation practice therefore has to start with analysing the characteristics of IT strategies in the construction industry.

### 4.4.1 The diffusion of IT strategies

Only 25% of the respondents have a written IT strategy and 74% do not (1% do not know). This is a bit lower than the findings of (CICA & KPMG Peat Marwick 1993) which states that about 1/3 of the construction companies (in UK) have a formal IT strategy. The difference could be due to a difference in the responding companies size in the two surveys (the CICA and KMPG Peat Marwick survey were with large sized companies only). In another survey (Hochstrasser & Griffiths 1991) identify a similar tendency (compared to the latter) with only about 1/3 of the responding companies having a corporate IT strategy. This despite that, the responding companies in their survey were generally larger in size and represented several industries that have a reputation for better IT exploitation than the construction industry.

Analysed with respect to company size it is found that 11% of the small companies have a written IT strategy, whereas the percentage is 56% and 71% respectively for medium and large companies (see *Figure 12*).

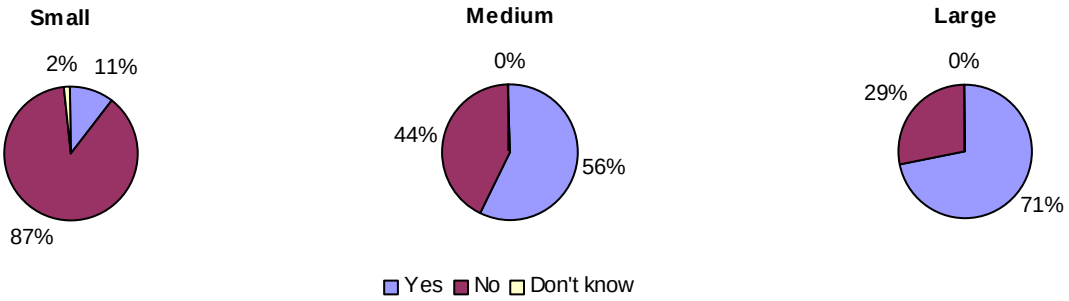



*Figure 12. Existence of a written IT strategy (small (<20), medium (<100) and large companies (100+))*

*Figure 12* shows, as expected, that the size of the company has an influence on whether they have a written IT strategy and that the proportion of large companies that have a written IT strategy is bigger than for small companies. When analysing the data with respect to type of company no clear trend can be identified.

### 4.4.2 Content of IT strategy

For those companies that have a written IT strategy the content is examined. The responses are analysed with regard to which elements the companies have included in their IT strategy. The percentage of companies with a written IT strategy, where a number of pre-defined elements is included, is shown in *Figure 13*. It is found that 95% of these companies have a description of their visions in the written IT strategy but, when it comes to specification of important business areas, specification of criteria and specification of means, the percentage drops to between 40 and 50%.

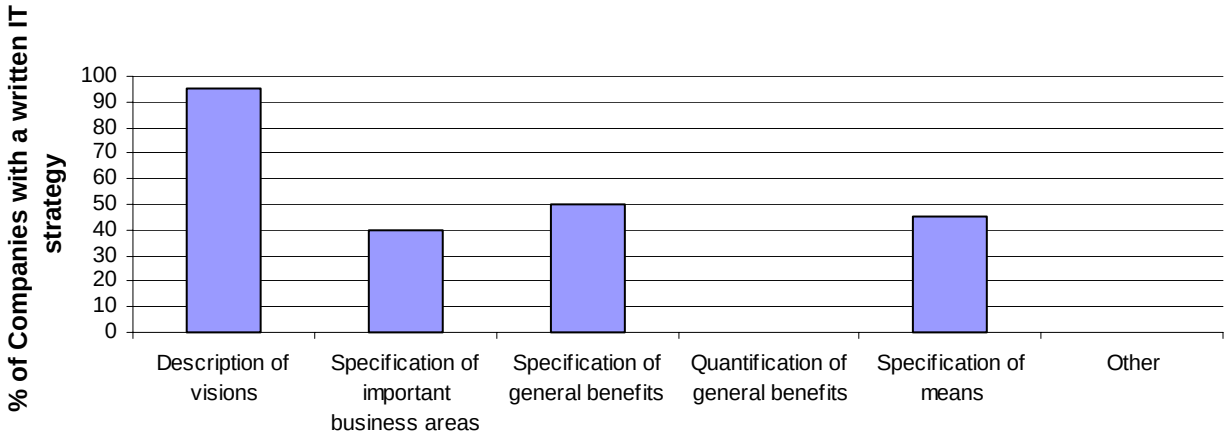



*Figure 13. Elements in the written IT strategy*

None of the companies quantify the criteria stated in the written IT strategy. This is not good because the employees might, owing to missing targets for their usage of IT, feel a lack of motivation and, furthermore, without targets for the business processes' use of IT, how is it possible to identify the success of the IT usage. The company size and type seems not to have a significant influence on which elements are included in the IT strategy.

### 4.4.3 Criteria used in the IT strategy

The analysis of the survey also focused on which criteria the companies use when they set targets for their future IT usage. Most companies put emphasis on the criterion *Quality improvements* as a target for their use of IT (see *Figure 14*). Three other criteria are also often addressed: *Time reduction, Client satisfaction* and *Employee satisfaction.*

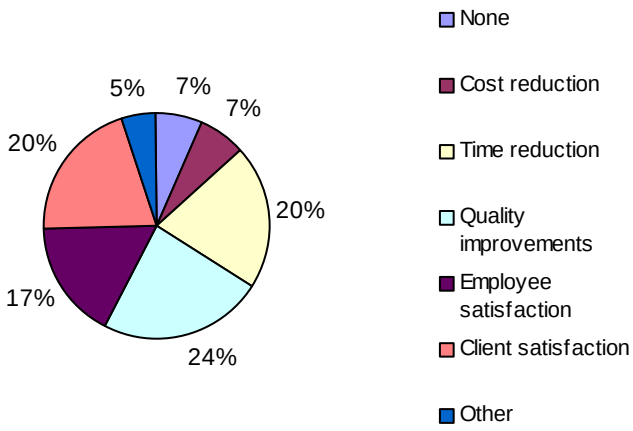



*Figure 14. Criteria used in the IT strategy*

Surprisingly, the criterion *Cost reduction* is rated low (7%) especially when considering that many IT systems used in construction are primarily giving benefits in this area (see (Howard 1998a;Howard 2001) and *Figure 16*). (Ward, Taylor, & Bond 1996) also identify a mismatch between drivers for IT investments and perceived benefits from current IT use. In their survey they identify the perceived benefits as heavily biased towards costs savings whereas major drivers like quality, customer service and business necessity are not perceived as current benefits. This tendency might be explained by the possibility that IT investments which are primarily focused on cost reduction have already been implemented and therefore the need for IT investments that fulfil this criterion is considered low by the companies.

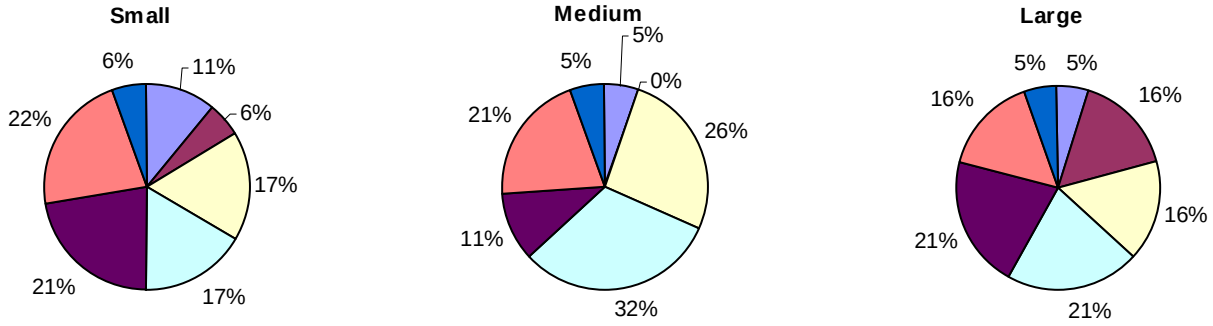



*Figure 15. Criteria used in the IT strategy (small (<20), medium (<100) and large companies (100+))*

The criteria used in the written IT strategy, when the data is analysed with regards to company size, reveals a different picture (see *Figure 15*). Small companies tend to focus on *Client satisfaction* and *Employee satisfaction*, where most medium-sized companies use *Time reduction* and *Quality improvements* and large companies use *Quality improvements* and *Employee satisfaction*. Analysed with regard to company type, it is found that architects mostly focus on *Client satisfaction* and *Employee satisfaction* whereas consulting engineers use *Time reduction* and *Quality improvements*, and lastly the contractors use *Time reduction* and *Client satisfaction*. The shift between hard and

soft criteria for architects, consulting engineers and contractors is interesting because this reflects the nature of their activities.

### 4.4.4 Comments on companies strategic plans for IT usage

Overall it can be concluded that a surprisingly low number of the responding companies have an IT strategy. If this reflects the whole Danish construction industry, then it means that the strategic use of IT is not planned and therefore cannot be managed satisfactorily in consistency with the companies' more general strategic plans. The reasons for this are probably many, but it is the experience that many companies are frustrated by the incredible speed in the development of new IT systems and therefore have enough to concentrate on just in order to keep up with the pace. This is, on the other hand, not a satisfactory argument because, in this dynamic development, there is probably an even greater need for an IT strategy.

Another interesting aspect can be derived from this fact. It is evident that, without an IT strategy, it is not possible to evaluate the IT investments with respect to their strategic contribution. As many IT investments in practice are justified on this criterion (see *Figure 20*) it indicates that these IT evaluations are completed without a solid foundation.

## *4.5 IT evaluations*

The second major area analysed is about how companies currently evaluate their IT investments. As indicated this analysis takes a life-cycle approach to IT evaluations meaning that the responding companies have answered questions about their IT evaluation practice with respect to 5 different stages that are defined as valid for all IT systems' lifecycles. Further information on the definitions of each stage in the life-cycle is found in chapter 9.

The companies' IT evaluation practice is analysed with respect to the following questions:

- Which of the used IT systems are also evaluated (both ex-ante and ex-post)?
- How often do the companies evaluate their IT systems?
- Which procedures are the companies using when evaluating?
- Which criteria are they using when evaluating?

The answer to these questions will, in combination, reveal how companies from the construction industry evaluate their IT investments.

### 4.5.1 Current use of IT systems and their evaluation

The first analysis is about which IT systems the companies from the construction industry are using and which they are evaluating.

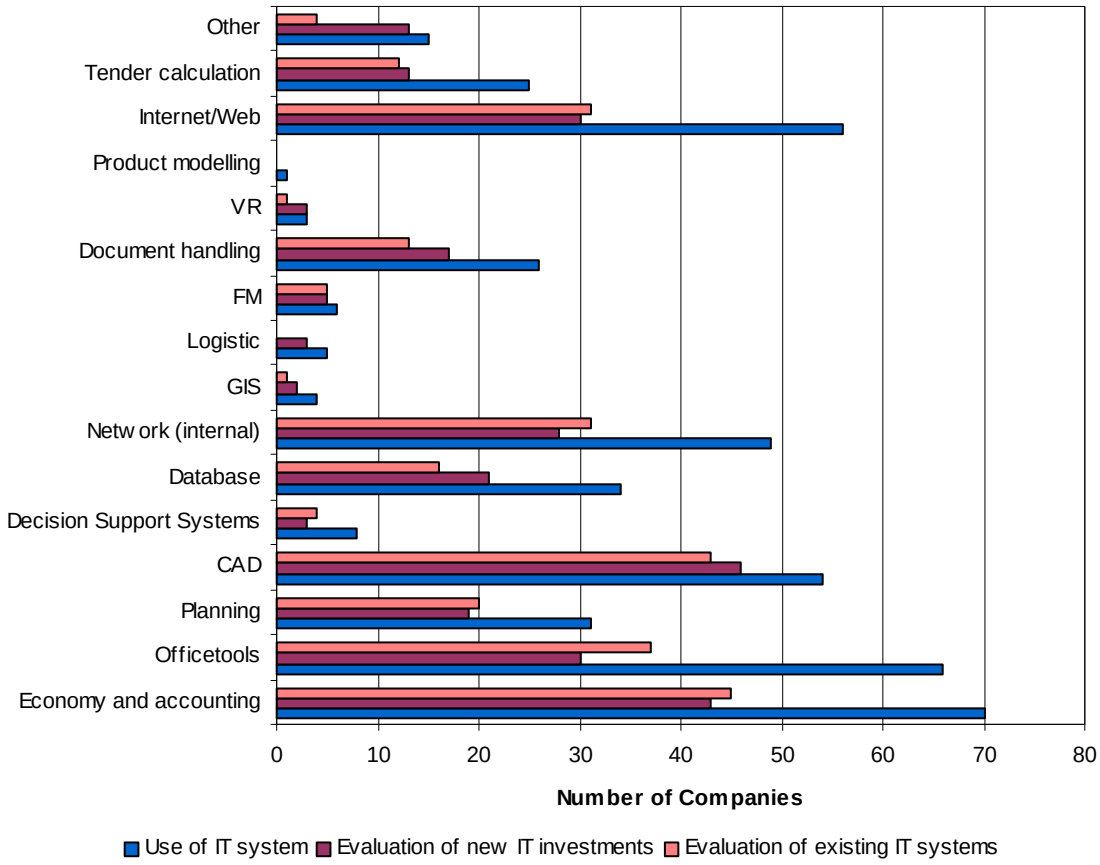



*Figure 16. Use of IT systems compared to frequency of evaluation*

The five most used types of IT system are, in prioritised order (shown in *Figure 16*).

1. Accounting and economy
2. Office tools
3. Internet/Web
4. Computer Aided Design (CAD)
5. Network (internal)

None of the top five IT systems are regarded as specifically designed for the construction industry. CAD systems are, however, used to a great extent in building projects, whereas the other four IT systems are considered as general company systems. The companies' usage of IT systems shows similar tendencies to those found in the IT Barometer surveys (Howard 1998a;Howard 2001).

The most evaluated IT system (calculated as the sum of the ex-ante and ex-post) is, as expected, CAD (however, closely followed by *Economy and accounting*). CAD systems are, by most companies, regarded as important to their business activities and hence they are the IT systems evaluated most. Earlier CAD workstations were also extremely expensive (some may argue that

they still are) and the companies had to ensure that their choice was the best possible. The figure shows that only about 50% of the respondents who use the systems: *Economy and accounting*, *Office tools*, *Internet/Web* and *Network (internal)*, also evaluate them. This tendency may be due to these systems being generally accepted as beneficial.

### 4.5.2 Frequency of IT evaluation

In the survey the frequency of the responding companies' IT evaluations during the IT system life-cycle has been analysed (see *Figure 17*). Not surprisingly, it reveals that the companies evaluate most frequently before the IT investment is approved (about 56% of the respondents evaluate IT investments either always or frequently in *Before investment*). The percentage drops to between 20-30% in the later stages.

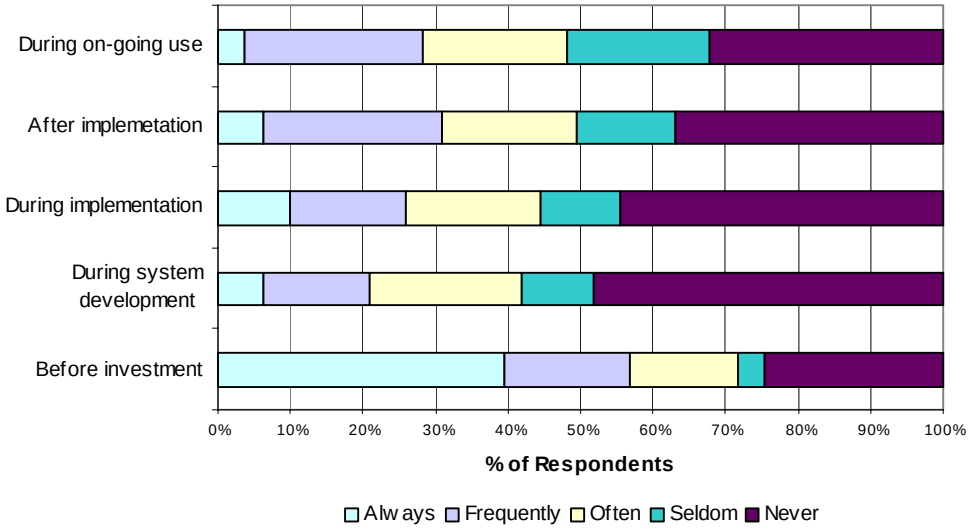



*Figure 17. Frequency of IT evaluation*

Another significant finding is that the percentage of respondents that never evaluates IT systems is worryingly high, ranging from about 25% to nearly 50% of the responding companies in the five stages. This means that a high proportion of the companies are either not estimating or measuring the value of their IT usage. This is despite the increased spending on IT which has been identified in a previous section of this chapter. In the stage, *During system development*, nearly 50% of the companies never evaluate their IT investment. This result may, however, be due to most of the IT systems used in construction being off-the-shelf systems, which means that the software development is done by the software producers.

Analysed with respect to company size, it shows that all the large companies evaluate their IT systems at some stage of the IT evaluation life-cycle and that above 70% always evaluate in the stage, *Before investment*. The proportion of companies that never evaluate IT systems in the different stages, is higher for small and medium-sized companies than for large companies. This tendency has also been found by (Ballantine, Galliers, & Stray 1996). They also conclude that companies with a large IT budget (mean £8 million[10]) tend to have a higher frequency of IT evaluation than companies with a low IT budget (mean £1.1 million). These findings are, in combination, indicating that large companies in general evaluate more often than both small and medium-sized companies.

[10] £1 was approximately worth 11.8 DKK on 20/09-01

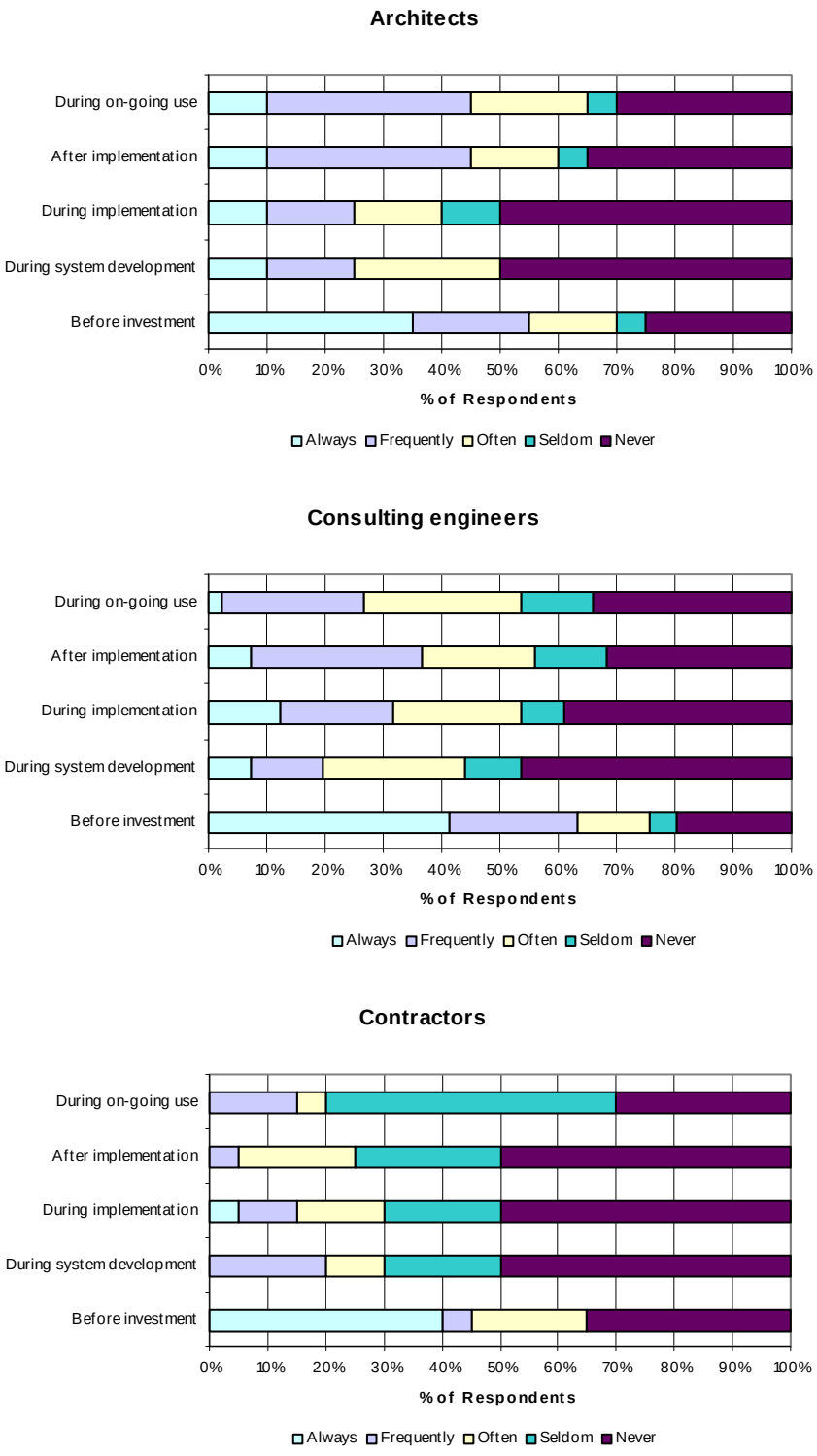



*Figure 18. Frequency of IT evaluation (architects, consulting engineers and contractors)*

Comparing the three charts displayed in *Figure 18* it is found that consulting engineers have the highest frequency of IT evaluation (about 62% always or frequently evaluate their IT investments) in the stage, *Before investment*. They are, however, closely followed by the architects (55%) and, lastly, the contractors (44%). When conducting ex-post evaluations architects have the highest frequency (45%) followed by consulting engineers (28-37%) and again contractors (4-15%) as the company with the lowest frequency. Generally this indicates that contractors do not often conduct

IT evaluations, whereas consulting engineers have the highest frequency of IT evaluations of the three types of companies.

A Finnish cross-industrial survey identified a higher frequency of IT evaluation where about 80% of the respondents always, or frequently, conduct IT evaluations compared to about 58% in this survey (Hallikainen, Heikkilä, & Saarinen 1997). In an English survey, (Willcocks & Lester 1994) found a frequency of IT evaluation which is higher than both the Finnish survey and this survey (the frequency is however not measured in the same way). For example they identify that all of the responding organisations (representing different company sizes and industries) completed IT evaluations in the feasibility stage (which corresponds to the *Before investment* stage in this survey) and 66% in all stages (Willcocks & Lester 1994). This could indicate that UK companies have a better attitude to conducting IT evaluations than both Danish and Finnish companies. When comparing the large companies' frequency of IT evaluation (as found in this survey) there is better harmony between the three surveys. This means that, if the responding companies in the Finnish and English surveys are assumed to be about the same size as large companies in this survey, then the difference between the different industries' frequency of IT evaluation is small.

*Figure 17* shows that ex-post IT evaluations are completed with a significantly lower frequency than ex-ante evaluations. In the stages, *After implementation* and *During on-going use*, respectively 6 and 4% of the responding companies always evaluate their existing IT systems. Surveys showing the same tendency have been reported by a number of sources (Farbey, Land, & Targett 1992;Hallikainen, Heikkilä, & Saarinen 1997;Ward, Taylor, & Bond 1996;Willcocks & Lester 1996) but they report in general higher frequencies than found in this survey. This tendency is worrying, as companies cannot determine whether they actually achieve the benefits claimed in their ex-ante evaluation if they do not conduct ex-post evaluations. A number of reasons for this can be identified. First, the evaluator might not be interested in completing the ex-post evaluation because the IT investment's cost/benefit ratio was deliberately overrated in order to get it approved (this has been reported by (Ward, Taylor, & Bond 1996)). Secondly, many managers might believe that as long as the IT system is running, benefits are achieved. This belief is, in many cases, true but can also turn out to be a false belief. Lastly, completing ex-post IT evaluations is considered by many companies to be more difficult and expensive than ex-ante evaluations and may therefore be skipped if there are time or cost constraints.

### 4.5.3 Procedures used in IT evaluations

The next aspect analysed is the procedure used when evaluating the IT investments (see *Figure 19*).

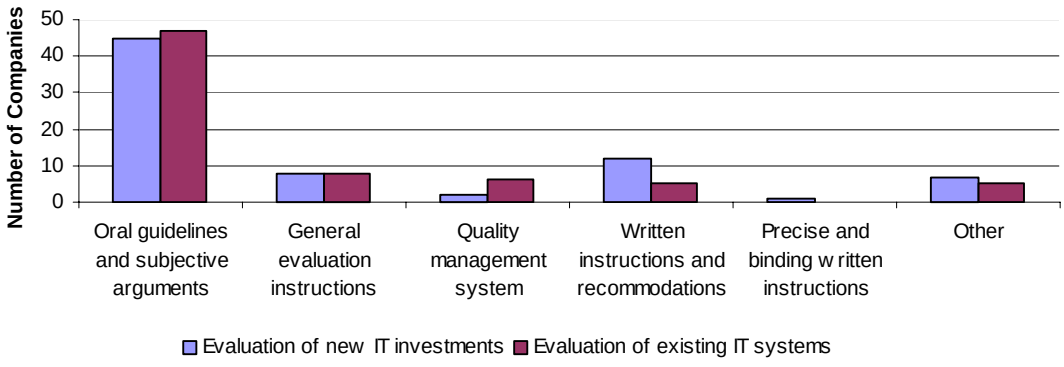



*Figure 19. Procedure used in IT evaluation*

The procedure used when completing an IT evaluation is, in most of the responding companies, based on *Oral guidelines and subjective arguments* (in all three types and sizes of company). Similar findings in relation to the construction industry have been stated (CICA & CIRIA 1995) as well as in other cross-industrial surveys (Ballantine, Galliers, & Stray 1996;Farbey, Land, & Targett 1992;Hallikainen, Heikkilä, & Saarinen 1997;Willcocks & Lester 1994).

*Figure 19* shows that the percentage of respondents using procedures that are specifically designed for IT evaluation, is low (17%). This implies that most IT evaluations do not consider the differences in evaluating IT investments compared to evaluating other investments. This could be due to lack of methods that fulfil the need in the construction industry or lack of knowledge of existing IT evaluation methods.

Hallikainen, Heikkila, & Saarinen found in their survey that the two most used IT evaluation procedures were *Oral guidelines and subjective arguments* and *General investment instructions used in the company* (Hallikainen, Heikkilä, & Saarinen 1997). This corresponds well with the findings in this survey as seen in *Figure 19*. (Willcocks & Lester 1994), however, found a relative high use of formal IT evaluation procedures in the 50 companies surveyed. Compared to the findings in this paper it seems that the IT evaluation procedures used in the construction industry are more informal. Small companies tend to rely more on *Oral guidelines and subjective arguments* than medium and large companies. With respect to company type, it is found that more contractors use informal procedures than both architects and consulting engineers. This is in contrast to the findings in (CICA & CIRIA 1995), where more consultants than contractors used informal IT evaluation procedures. A part of the reason for this was identified to be that consultants write off the IT investments on their projects or that they will not get the projects without the IT systems.

### 4.5.4 Criteria used in IT evaluation

One of the objectives in the survey was to identify the type of criterion used in IT evaluation throughout the IT investment's life-cycle. A tendency towards a shift from "economic benefits" in the investment stage, to user-oriented benefits in the use stage was identified. The same tendency can be found in Hallikainen, Heikkila, & Saarinen's and Willcocks & Lester's survey (Hallikainen, Heikkilä, & Saarinen 1997;Willcocks & Lester 1996).

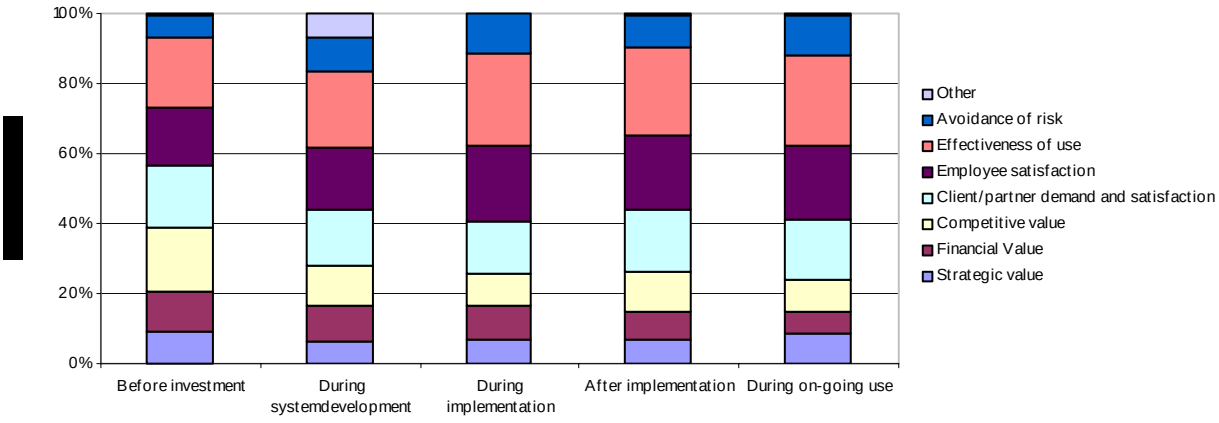



*Figure 20. Criteria used in IT evaluation*

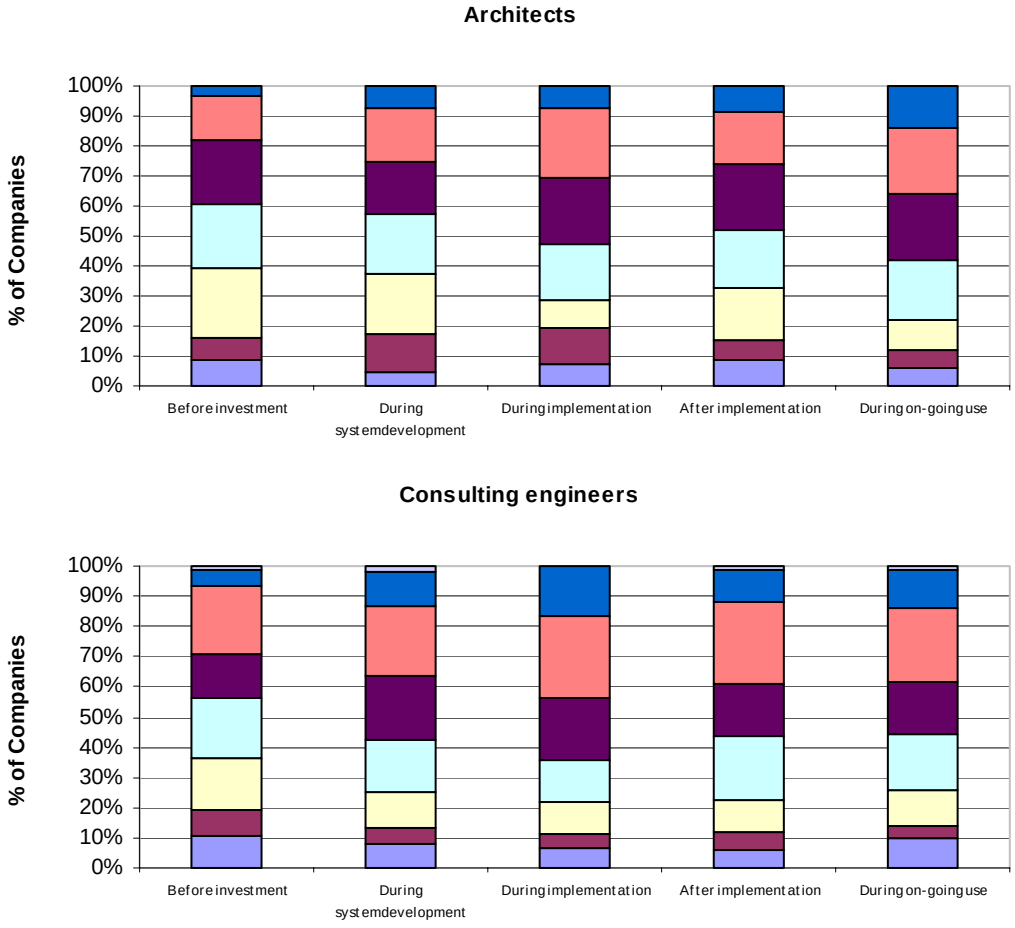
*Financial value* seems to have lesser importance compared to, for instance, *Employee satisfaction* and *Effectiveness of use* in all five stages. The reason may be that the importance of the IT investment's usability and effectiveness is bigger than cost savings achieved. In other cross-industrial surveys financial value is used as a criterion to a greater extent. For example (Hallikainen,

Heikkilä, & Saarinen 1997) found that financial profitability was rated as the most used criterion in the stage *Before investment* and (Willcocks & Lester 1994) found in their survey that 62% of the companies used the analysis of cost/benefit as their predominant evaluation criterion. Many of the criteria used in practice (as illustrated by *Figure 20*) are difficult to quantify, which is further underlined by the fact that about 76 % of the respondents are not quantifying the criteria used in their IT evaluations.

The criteria used when evaluating IT investments are, when compared to the criteria for the companies' IT usage overall, in harmony. Much weight was put onto criteria like *Quality improvements*, *Time reduction*, *Client satisfaction* and *Employee satisfaction* in the usage of IT whereas little weight was put on cost reduction and the same tendency was also identified in *Figure 20*.

The shift from economic benefits in the investment stage, to client and employee satisfaction in the use stage is most clearly identified in small and large companies. Large companies' focus in most stages is primarily on the criteria *Effectiveness of use* and *Employee satisfaction* except at the stage *Before investment*, where 40% are using *Financial value*, *Strategic value* and *Competitive value*.

Analysing the criteria used in IT evaluation with respect to the type of company (see *Figure 21*), it is found that contractors use two criteria heavily: *Employee satisfaction* and *Effectiveness of use* in all five stages, especially in the ex-post evaluation (*After implementation* and *During on-going use*) where the criterion is used by more than 60%.



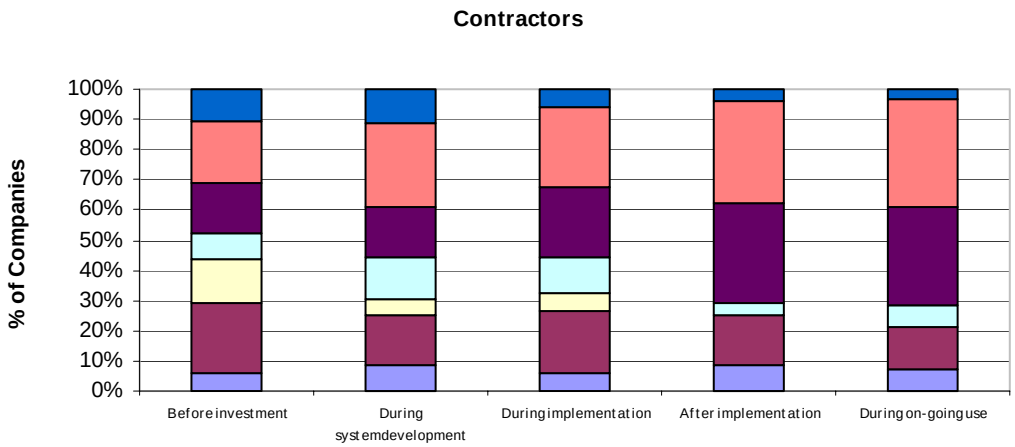



*Figure 21. Criteria used in IT evaluation (architects, consulting engineers and contractors)*

By comparing the charts in *Figure 21*, it is found that the criterion *Competitive value* is more used by architects and consulting engineers than contractors. This tendency may be due to greater focus on the competitive environment because of hard competition. Contractors use the criterion, *Financial value*, more than both architects and consulting engineers, most likely because they are competing more on price than the two other types of company. For all three types of company it is found that the criterion, *Strategic value*, is little used when evaluating IT investments, which may be explained by the low rate of companies with a written IT strategy.

### 4.5.5 Comments on IT evaluation practice in construction

In general there is strong indication that companies from the Danish construction industry are evaluating their IT investments mostly by using informal IT evaluation procedures such as oral guidelines, whereas more formal procedures are only used in rare cases. This, together with the fact that very few companies complete ex-post IT evaluations, strongly indicates that the IT evaluation practice is relatively poor.

This is further highlighted by a number of cross-industrial surveys that identify a higher level of IT evaluation practice in both other industries and countries.

The survey also found that 59 % of the respondents cannot document the effects of using IT systems which indicates a need for an increased focus on IT evaluation. In general the evaluation of IT systems in the Danish construction industry seems to be unsophisticated compared to the methods researchers are working with. This implies a need for more dynamic and practical IT system evaluation methods which fulfil the needs of the construction industry, and that the knowledge of existing IT system evaluation methods is generally low today.

All in all it is argued that companies should focus more on how they evaluate their IT investments. An important step in doing this is that the companies recognise the need for improved information on what they achieve from the money spent on IT, and this can only be achieved by evaluating more thoroughly than was found in this survey.

## 4.6 Use and development of current IT evaluation practice

The last part of the survey focused on how the companies use the results achieved from the IT evaluations. Are they often rejecting IT investments as a consequence of the evaluation? Both the actions based on the ex-ante and the ex-post evaluations are analysed.

The second issue addressed in this section is how companies improve their IT evaluation practice. This is done by questioning the companies' frequency of, for example, searching for new and better IT evaluation procedures.

### 4.6.1 Use of output from IT evaluation

The first aspect addressed is about how often companies reject, change or approve IT investments as a consequence of the output from their ex-ante IT evaluations. The responses from the companies can be seen in *Figure 22*.

The most notably finding from the figure is the very high frequency of accepting IT investments without or with minor changes. The frequency is found to be about 36% that frequently or always approve the IT investments without or with minor changes. (Hallikainen, Heikkilä, & Saarinen 1997) found that more than 60% of the companies frequently or always approved the proposed IT investment. This is considered a high frequency which indicates that the majority of IT investments are approved as originally proposed. The high percentages can be explained by an IT investment not being proposed unless there is a good chance of its approval.

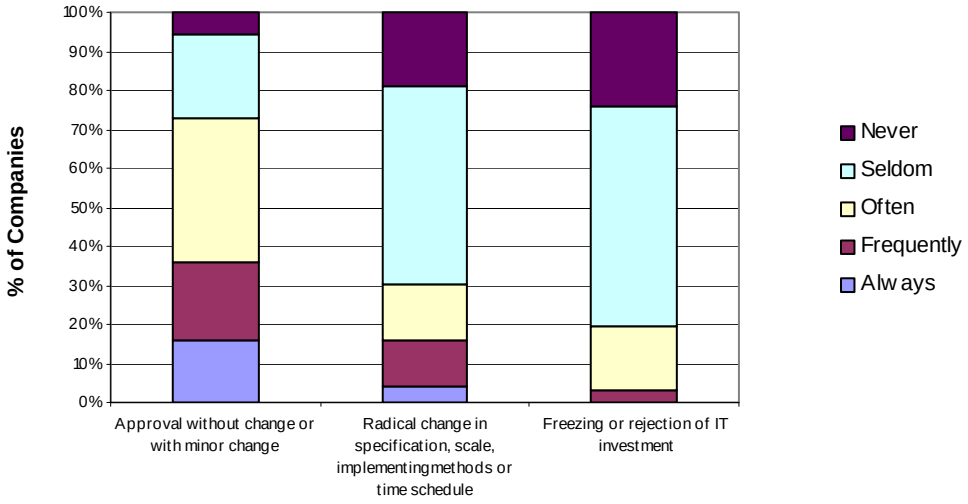



*Figure 22. Frequency of actions as a consequence of evaluation of IT investments*

By examining the tendencies shown in the *Figure 22*, it is shown that the proportion of companies that always or frequently make the described action are decreasing the more drastic it is. 16% of the companies always or frequently make radical changes in specification, scale, implementation method or time schedule, of the proposed IT investments. The proportion of companies that frequently freeze or reject the IT investment is about 3%. Similar findings (respectively about 15% and 3%) have been identified by (Hallikainen, Heikkilä, & Saarinen 1997).

Examining the same aspect of ex-post evaluations, the same tendency can be identified. About 31% of the companies either always or frequently approve the existing IT system with or without minor change. 18% always or frequently make radical changes and 2% frequently stop using the IT investment. The same tendency is identified by (Hallikainen, Heikkilä, & Saarinen 1997).

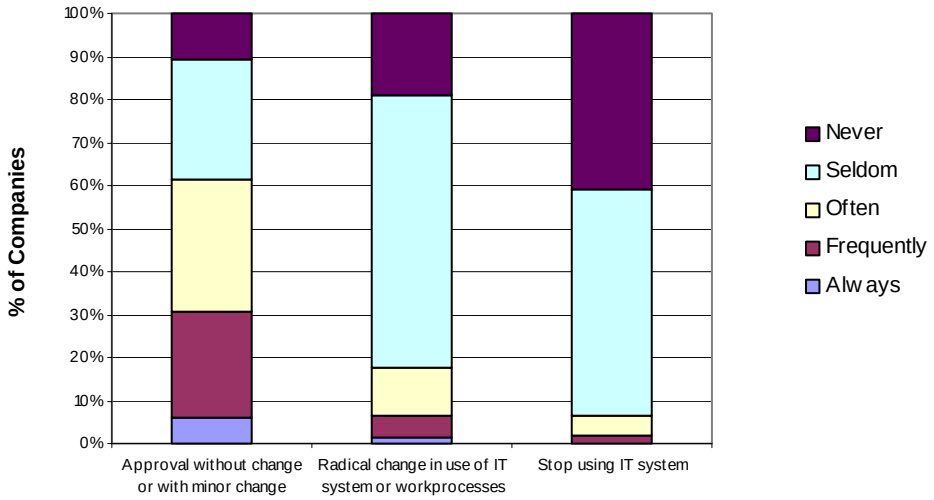



*Figure 23. Frequency of actions as a consequenceof evaluation of existing IT systems*

The analysis also reveals that the responding companies less frequently initiate the three described actions as a consequence of ex-post evaluations as they do for ex-ante evaluations. This result is not surprising, as companies in general are more hesitant to make critical decisions once the IT system is in use. There is, however, one problem connected to this practice. If (or more likely when) an IT system turns out to be unable to deliver the required benefits and functionalities during the ongoing use then the IT system should be either changed or stopped (or be upgraded to a newer version). Otherwise the IT system may have negative effects on the company and may even create significant problems that require extensive resources to solve in the longer term.

### 4.6.2 Developments in evaluation practice

This last aspect analysed is focused on how the companies improve their procedures and techniques used when conducting IT evaluations. Four different initiatives are defined (se *Figure 24*). Each of these is used to examine the companies' development of their IT evaluation practice.

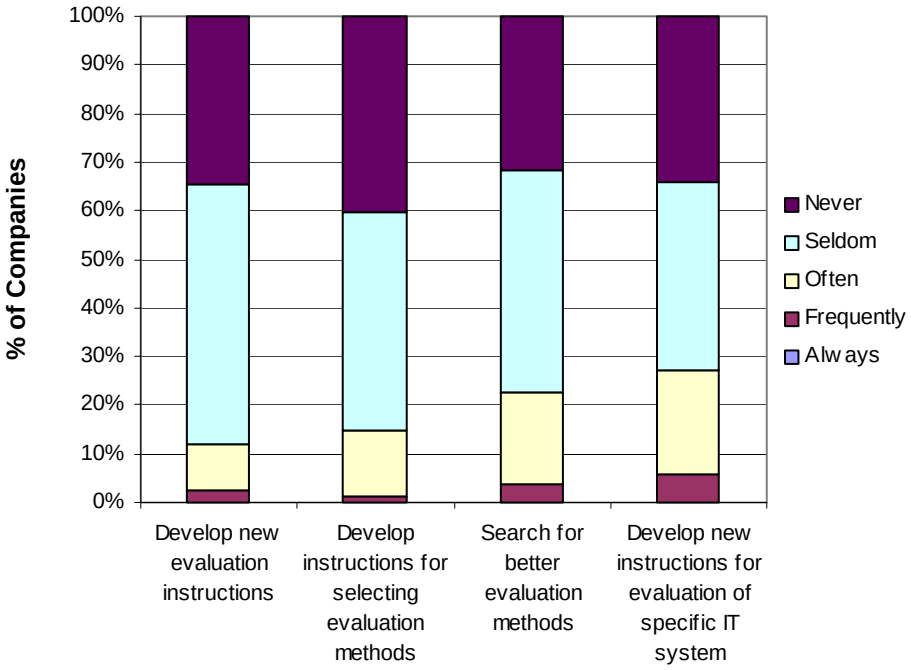



*Figure 24. Frequencies of initiatives in the development of the IT evaluation practice*

Analysing the responses from the companies it is found that a large proportion of the companies seldom or never develop (nearly 90%), or search (nearly 80%) for, better ways of evaluating IT. The identified tendency as shown in *Figure 24* is poor because the companies are not considering how they ideally should evaluate their IT investments. Two reasons might explain this tendency. The first reason could be that the companies are satisfied with their current knowledge and management of IT, or because they simply have accepted that "our current practice is the only practical way of evaluating IT". This is however not the general response from the companies as found by various sources (Ballantine, Galliers, & Stray 1996;CICA & CIRIA 1995). Secondly, a possible reason may be that the companies are not aware of the many available IT evaluation methods and are therefore not searching for any. Neither of these mentioned reasons can justify the frequency of initiatives.

## 4.7 Summary

In this chapter it has been indicated that only a few companies from the Danish construction industry have an IT strategy and especially small companies have a poor level of adoption.

In general there are strong indications that IT evaluation practice in Danish construction is less advanced than in other industries. This has been revealed through a high use of informal IT evaluation procedures and a low frequency of IT evaluations during an IT investment's life-cycle.

The initiatives from the companies on improving their IT evaluation practice are also found to be low.

Two parameters have been identified as influencing the IT evaluation practice.

- Company type
- Company size

# Part II

# Case studies

Five case studies, in which four selected IT evaluation methods are completed, are presented and analysed. The output of the methods is presented and the directly derivable conclusions are commented on. The findings are used in the development of the framework.

# Chapter 5: Case study descriptions

This chapter describes five case studies in which the four IT evaluation methods selected (see chapter 3) have been used in practice.

The first part describes the methodology used in the case studies. The presentation will focus on the case study objectives, choice of methodology for data collection, the case study process and the selection of case studies. The second part describes the case studies with a focus on three areas; the company, the IT evaluation and the IT investment.

The description of the case studies will provide the basic knowledge of the case studies needed to understand the findings in chapter 6 and 7. It contains the description of some of the case studies' characteristics needed to test the framework (see chapter 12).

## *5.1 Case study objectives*

The objectives of the case studies can be divided into four different areas. Each of these is to some degree interlinked.

The primary objective of the case studies is to try out different IT evaluation methods on different types of companies and IT investments. The four methods used are described in more detail in chapter 3. Two important aspects can be examined by completing these methods in real-life IT evaluations. Firstly, it can be seen how the methods support the IT evaluation in each of the case studies. Secondly, identification of the influencing parameters on the methods' usefulness in the IT evaluations can be completed.

The aim of using four different methods in different case studies is to collect information on the usefulness of each of the methods in the actual IT evaluation and the parameters that influence its usefulness.

The second objective is to identify and describe different types of IT evaluation. IT evaluations are very different from each other because they are made up from many factors like, for example, use of evaluation criteria, stage of IT evaluation, etc. Completing a series of case studies will provide data on different types of IT evaluation which are useful in the development of the framework.

Identifying different types of IT evaluation will be used to base the guide on how to choose the best IT evaluation method. The number of different IT evaluations is theoretically unlimited and collecting data on different scenarios would therefore be a never-ending task. Because of practical limitations the number of case studies was chosen to be either four or five. This limits the scope of the case studies but it was nevertheless considered a necessary limitation.

The third objective is to experience and identify the problems an IT manager (the IT evaluation champion) faces in practice when conducting IT evaluations. Completing the IT evaluations will provide some data about the problems of evaluating IT investments by using one of the four methods.

The practical problems experienced, together with a theoretical review of the four IT evaluation methods' strengths and weaknesses, will give the reader an overview of the barriers in conducting

IT evaluations. Collecting data on problems in conducting IT evaluations can be used to describe how IT evaluations can be improved in the construction industry.

The last objective is to collect data on typical IT investments that either a consulting engineer or a contractor might need to evaluate in the future. The IT investments evaluated are intended to be relevant to companies from the construction industry.

Collecting and presenting information on how different IT investments, which are relevant to companies from the construction industry, impact on a company can be used by other companies whenever they are facing similar IT investments. It is, in this context, very important to stress that the IT evaluations are very context dependent, meaning that the results from the case studies cannot be regarded as directly applicable to other companies. It may, however, give some insight into the impact of the IT investment that might be useful to some companies.

## 5.2 Case study methodology

Completing four different IT evaluation methods is a very time consuming process and requires a good overview of the progress made throughout the case studies. This section provides an overview of the stages completed in each of the case studies, whereas the stages needed to complete each of the methods are described in chapter 3.

Some of the methods (NPV, MBITI and IE) include the same type of data (the economic data) and it was therefore decided to complete the identification and estimate of the costs and benefits in common instead of repeating it three times. This may not reflect a true usage of these methods but it was judged that this process would not be significantly different from completing the methods separately. In those situations where the methods required some special economical data they were completed separately.

### 5.2.1 Stages in the case studies

The case studies were completed using several more stages than would have been necessary if only the methods had to be completed (see eventually chapter 3). The reason is that more data than necessary to fulfil the data needs of the methods, was collected in order to describe the company, the IT evaluation and the IT investment.

The stages completed in each case study are described in the following.

- **Describing the company**
  The first stage is focused on describing the company with regards to the following areas: strategy, organisation, technology, human resources, objectives and environment. The primary objective of this stage is to collect data about the company and to get an insight into the characteristics of the company.
- **Describing the IT investment and the IT evaluation**
  The second stage focuses on describing the IT investment that is in focus in the case study, and on which the four IT evaluation methods have to tested. This stage is also focused on describing the IT evaluation with regard to the purpose of evaluation, stage of IT evaluation, desired format of the methods' output, etc. The primary reason for doing this is to identify and describe the IT investment and the IT evaluation.
- **Describing the company's IT evaluation practice**
  In this stage the company's IT evaluation practice is identified and described. The focus is on how the company evaluates its new IT investments or its existing IT systems. The

primary objective of this is to identify how advanced (or mature) the company's IT evaluation practice is.

- **Identifying the lifetime of the IT investment**
  Only one parameter (although very important) is estimated in this stage. The time of the IT investment's operational life is estimated. This should be estimated on the basis that no major investment or upgrading is necessary during this period.
- **Identifying the costs and benefits**
  This stage is the first step in completing the economically based IT evaluation methods (NPV, MBITI and IE). Identifying the costs and benefits of using the IT investment is a common element of these methods and is therefore only completed once. There is, at this stage, no limitation on the types of costs and benefits identified.
- **Categorising the benefits**
  This stage focuses on categorising the benefits into three: financially measurable, measurable (but not economically) and not measurable. This is an important stage, as it has a great influence on the financially oriented methods.
- **Estimating costs and benefits**
  After identifying and categorising the benefits, the estimate of each benefit's value is completed. The estimate of the benefits' value is completed on a yearly basis and is only done for the financially measurable benefits. Also the costs are estimated using two categories: development and running costs.
- **Completing NPV**
  In this stage the method NPV is completed. Most of the data needed for this method were already collected in the two previous stages. One specific parameter, the rate of interest, needs to be estimated in order to complete this method.
- **Completing MBITI**
  The second method completed is MBITI. Firstly, the strategic part of the method is completed and secondly, the three tables are filled out inputting the already identified and categorised benefits and their estimated attributes. The presentation sheet can then be completed on the basis of the three tables.
- **Completing IE**
  This stage focuses on completing the method IE. Three different domains are completed: the economic, the strategic and technology domain. Lastly the company weightings of each of the factors, which are marked in the three domains, are estimated. On the basis of this the total value and the total risk can be calculated.
- **Completing CSF**
  The last of the four methods, CSF, is completed in this stage. Several interviews with different stakeholders are completed and a list of critical success factors is generated.
- **Writing the case study report**
  When all the data collection is complete the final report on the case study is written. The report outlines three aspects of the case study. Firstly the description of the case studies, secondly, the testing of the four methods and thirdly, the conclusions about the output provided by the methods.

In total 12 stages are completed in each case study, however, the individual case study might have been completed slightly differently to those outlined above

### 5.2.2 Data collection methodology

Basically four types of data sources have been used with advantage in the case studies. A brief description of these is completed below.

- **Interviews**
  In total 25 meetings, arranged as semi-structured interviews, were recorded on tape and a summary was written for each meeting (these can be found in the Appendices). The written summary was then sent to the interviewee for comments and ultimately for approval. The interviews were completed with different types of people depending on the requirements, but most of the meetings were with the case study company's IT manager.
- **Meetings**
  Most of the methods' data collection (e.g. the identification and estimation of the costs and benefits of the IT investments) was collected in meetings with one or more persons. In total 30 meetings were completed. In general the author of present dissertation was the chairman of the meetings held. The meetings were not strongly chaired and this allowed for some flexibility of the meeting agendas. These meetings were not recorded on tape but the tables, spreadsheets etc. produced serve as the documentation of the meetings.
- **Questionnaire**
  For each case study a questionnaire, the same as the one used in the survey, was completed focusing on the company's IT evaluation practice. The questionnaire serves two purposes. First, as describing the company's IT evaluation practice and second, to establish a link between the questionnaire survey presented in chapter 4, which focuses on the Danish construction industry's IT evaluation practice, and the case studies.
- **Documents and homepages**
  The last source of data was collected through documents and homepages. The documents are, for example, the companies' annual reports, other reports, descriptions of IT applications, etc. The Internet was also used by, for example, accessing the companies' homepages, the IT applications' homepages, etc. The data collected through these media were, however, not used as the main source of information.

## 5.3 Selection of case studies

Four important criteria for the case study selection were used. These are described in the following.

The companies, who participated in the case studies, were selected as either consulting engineers or contractors. This limitation was mainly decided because the number of differences between the case studies should not be too large, otherwise this would result in a significant difficulty in deriving comparative conclusions (Yin 1994).

The case studies were also chosen on the basis of the type of IT investment that was about to be evaluated. Primary IT investments with relevance to the construction industry were chosen because their potential users are assumed to be working within this business. There are examples of IT investments that are generally used within all kind of business e.g. payroll systems, and these were, if possible, not chosen.

A third criterion used to select the case studies was, where possible, an actual need for evaluating an IT investment in the company. The main reason for this criterion is that the company should be genuinely motivated to complete the IT evaluation and not just consider the IT evaluation as an academic exercise. This means that the company is more likely and more willing to spend some resources on completing the IT evaluation than if they consider it as an academic exercise.

The last, but maybe the most important criterion, was to complete a number of case studies so there is a basis for fulfilling the objectives of the case studies. Few companies are, in general, interested in providing possibly sensitive data/information, and that fact limited the availability of potential

case studies. This implies that almost all the case studies, that were available at the time, were selected.

## 5.4 Presentation of the case studies

The five case studies were selected by using the criteria described above. The selection process ended up with three of the case studies being with consulting engineers and two with contractors.

### 5.4.1 The five companies

The five case study companies are briefly described with respect to the following:

- General characteristics (size, no. of employees, core business activities etc.)
- Usage of IT
- Current IT evaluation practice

The data used to describe the five case study companies with regard to above aspects, was obtained through a series of interviews and a summary of these can be found in the following Appendices B3, C2, D2, E3 and F2. A second source for obtaining the data has been the companies' most recently released annual report.

Lastly the data used to describe the company's current IT evaluation practice has been gathered through interviews (see Appendices B2, C3, D4, E4 and F4) and through the completion of a questionnaire (the same as used in the survey in Chapter 4). The responded questionnaires are found in the following Appendices B1, C1, D1, E1 and F1.

**Rambøll**

The first case study initiated was with Rambøll which is the third largest consulting engineer in Denmark with a turnover of 1,206 million DKK (roughly equivalent to $150 mill.) and 1,856 employees (1999 figures). The turnover in year 2000 has gone up slightly (to 1,273 million DKK) whereas the number of employees is approximately the same.

Its main business areas are consultancy within engineering disciplines (77% of turnover), IT (12% of turnover) and management (11% of turnover) in 1999 figures. The company is internationally represented and 23% of the turnover is coming from abroad.

During the past 10 years they have been involved in the design and construction of the two large bridges that have been built in Denmark. They have furthermore been involved in several research projects like for example Product- and Process development (PPB).

***The company's IT usage***

The company is primarily using IT as a support in their core activities (which in an abstract term can be characterised as knowledge), although they are heavily dependent upon, for example, their CAD systems. It is believed in the future that IT will have a greater importance and impact on their business activities.

The company uses a variety of IT applications such as office tools, accounting systems, DSS, CAD systems, EDMS etc. Some of their IT systems are considered as well integrated, for example their CAD systems, however, some potential benefits would be expected if their IT systems were better integrated. Most of their IT systems are off-the-shelf software but they are also developing specialist engineering software themselves (which is sold commercially).

### *The IT evaluation practice*

In general Rambøll's IT evaluation practice could be characterised as using the company's general guidelines for how to make decisions because there are no formal and standardised IT evaluation procedures for IT investments. Previously Rambøll had a decentralised organisational structure meaning that each individual division was responsible for its own IT usage. During the last three years, however, this has changed towards a more centralised management of IT.

Basically three types of IT investment are defined in the company: standard software, CAD software and technical software. The first type includes platform software, office tools (like spreadsheets, word processing etc.) and other IT systems that can be characterised as being used by the whole company. The second group consists of CAD software that is mainly AutoCAD and MicroStation. The last group consists of specialist software like HVAC design software. This group of IT systems is mainly decided upon by the different disciplines working in their respective areas. The three groups of IT investments are managed and evaluated within the groups that are responsible for them and all types of IT investments are evaluated before they are approved.

## Cowi

The second case study is with Cowi, the second largest consulting engineer in Denmark with a turnover of 1,354.1 million DKK and 1,530 employees (1997-98 figures). These went up to 1,377.3 million DKK and 2,087 in 2000.

Its main activity is consultancy within three engineering disciplines: Industry & Building, Traffic construction and Environment and planning. The company has offices in North America, Africa, Middle East, Asia and Europe.

Some of the larger projects Cowi has been involved in are the two large bridge projects in Denmark and some offshore construction. One of their most recent achievements is a result of their involvement in PPB, where they have designed a multi-floored timber house.

### *The company's IT usage*

The IT systems used in Cowi are not considered as a central element in their core business activities but some activities are, however, dependent upon their IT systems. They are currently planning to integrate their IT systems to a greater extent, especially some of their larger IT investments, because they believe there is great potential in doing this.

Cowi uses many different types of IT system and a few of these are:

- Administration systems
  - Accounting
  - Economy
  - Human management systems
- Technical business oriented systems
  - CAD systems (AutoCAD, MicroStation)
  - Documentum (placed in this group because of its ability for CAD drawings management)
- Communication, collaboration and knowledge management
  - Office systems (Microsoft Office etc.)
  - Groupware (Exchange/Outlook)
  - "Writing" systems (Layout, Customisation etc.)
  - Web based systems

The effects of the IT systems used focus on increasing the efficiency and effectiveness of the business activities within Cowi. Examples of this are quicker production of drawings, writing letters and an increased quality of the services Cowi offers to their customers. An extra benefit is the improved image to collaboration partners, customers etc. In other words the IT systems used in Cowi both enhance the efficiency and effectiveness of the company's business activities and improve the customer satisfaction with Cowi.

### *The IT evaluation practice*

Cowi does not use IT evaluation methods which use formal IT evaluation procedures, except for the cost/benefit analysis, which is seldom used. The company has some focus on conducting IT evaluations but is mostly focused on identifying the requirements and to ensure that the IT investment is technology that fits well into the company's current IT systems.

Cost/benefit analysis is mostly used for large IT investments. The cost/benefit analysis can, in Cowi's case, be considered more as an NPV method because they do not include the intangible costs and benefits in their calculation, and they calculate the present value of the cash flow.

In general Cowi's IT evaluation practice can be characterised as a little more advanced than just ad hoc because there are some tendencies to focus on improving their existing practice by, for example, evaluating the three core IT systems using some more advanced methods.

## NIRAS

NIRAS is the fourth largest consulting engineer company in Denmark and it focuses on a wide variety of engineering disciplines. The company's turnover was 325,301 DKK and it employed more than 600 (1999-2000 figures). The company is also represented in Greenland and Poland where it has some offices.

They provide interdisciplinary services within engineering, management and human resource development but they specialise in delivering consultancy services to construction related customers.

### *The company's IT usage*

The IT systems used in the company are considered as support for the core business activities and it is not the company's ambition to be in forefront of IT usage in the construction industry. Earlier NIRAS was more actively using IT systems as a way of innovating the company but this strategy has been changed because of the relatively large costs associated with such a strategy. The company has no plans to change the role of IT, because of its previous experience.

The IT systems used in the company are among others: Economy and accounting, office tools, planning tools, GIS etc. Common to these is the primary purpose of their usage, to increase the efficiency of the company's business activities.

### *The IT evaluation practice*

No formal IT evaluation procedures for how new IT investments should be evaluated are established, except for a general guideline stating that major IT investments should be approved by the executive committee. Only few IT investments are evaluated using a cost benefit analysis (and only if it is considered possible) in order to identify the improved efficiency benefit.

The operational level in the company usually identifies the need for an upgrading of an existing IT system or a new IT system. The need is often identified because an employee receives some files

that the company's IT systems cannot read or if a new IT system has entered the market. Almost all new IT investments are identified within the building project context.

Upgrading an existing IT system is often considered necessary because a lot of communication between the company and its partners takes place in building projects. Therefore this type of IT investment is often justified without a detailed evaluation.

**Højgaard & Schultz**

Højgaard & Schultz (H&S) is the largest Danish contractor with a turnover 3,985.3 million DKK and 3,126 employees (1999 figures) and has gone up to 4,360.2 million DKK in year 2000. The main focus is on construction and building activities but some capabilities in consulting engineering disciplines are also available in-house. The company is internationally represented, with approximately 20% of the turnover coming from subsidiaries in UK and Portugal. Recently (May 2001) the company joined with another large contractor (Monberg and Thorsen) and they thereby almost doubled their turnover to approximately 9 billion DKK. Their new name is MT Højgaard A/S. This merger happened after the case studies were completed and is therefore not considered.

Both engineering and construction tasks are carried out in H&S but their main activity is building and construction. All sorts of contracting tasks are done but one of the more significant ones is the Great Belt bridge.

***The company's IT usage***

Most of the IT systems used in H&S support the core business activities but they are not considered as a part of these. It is estimated that H&S would only be able to run for a week without its IT systems, and it can therefore be concluded that H&S is very dependent on them. This dependency has increased during the last 3 to 4 years where an increasing amount of communication is done using e-mail and intranet etc. This can be seen in the network bandwidth, use of Internet, e-mails and storage requirements.

In the future an increasing impact from using IT is expected and therefore the company expects to achieve more benefits but also to be more dependent on their IT usage.

A central IBM server (AS/400) is the connection point for the network across the whole country. Several types of IT system are used in H&S:

- Groupware
- Office package
- Economy system
- CAD systems

The output from using IT systems in H&S today is mainly to improve their collaboration both internally and externally. This is done by linking the IT systems together, allowing the employees to work across disciplines, distribute and assemble information. In general IT provides better facilities for collaboration and communication.

***The IT evaluation practice***

The primary reason why H&S evaluate their IT investments is to prioritise them. Many potential IT investments have to be evaluated in order to identify their desirability but, because there are so many making it necessary to be able to evaluate in a standardised way, this ensures that the output from the IT evaluations are comparable.

The IT department receives all the new ideas, wishes and proposals for new IT investments. No formal IT evaluation procedures are used when evaluating the IT investments. Typically the IT department prepares an initial proposal (an IT investment description) including a calculation of the cost of the IT investment. These are prioritised by the IT department and then presented to the board of division managers. They can then approve or reject the prioritisation or make minor amendments. Once the prioritisation is approved the actual work can begin. Later a few evaluation meetings might take place in order to follow the progress of the IT investments.

In general H&S's IT evaluation practice could be characterised as informal and is guided by the company's general practice on how to make decisions because there exist no formal and standardised IT evaluation procedures an IT investment.

**Troels Jørgensen A/S**

Troels Jørgensen A/S is a small contractor based on the island of Lolland (in a small town called Kettinge). Their turnover was approximately 100 million DKK and a staff of 275 (including the hourly-paid employees) (2000 figures).

The main business activities are construction works and buildings in the areas of Lolland and Falster, but it has also some activities in building material production e.g. pre-cast element fabrication.

***The company's IT usage***

Despite the company's small size it is considered as an advanced user of IT. This is partly because the company participated in European research in which the primarily objective was to increase the IT usage in small companies. Even though the company has a mature usage of IT compared to its size, the primary role of IT is to support the company's core business activities. This is not expected to be changed in future even though the company will be more dependent on their IT.

The following types of IT system were identified:

- Windows NT
- Concorde XAL.
- MS Office 2000.
- Lotus Notes enhanced by a few applications developed by Byg Data.
- AutoCad 14
- Handheld devices with an e-mail and a calendar facility (only the building site managers)
- 120 employees have home PCs.

Most of the IT systems used focus on increasing the efficiency of the existing business activities, and some of the IT investments focus on creating better working processes.

***The IT evaluation practice***

The company's IT evaluation practice is characterised as informal as the company is not using any formal IT evaluation methods or procedures. The primary reason for this is that the decisions taken concerning the company's IT usage are, in most cases, only an issue for three persons in the company, which makes the decision-making process easy and fast.

The decision-making process usually involves a software vendor giving an offer on a specific IT system which is installed if approved by Troels Jørgensen himself and the IT manager. Thereafter

the end users are instructed how to use the new IT system. Then, if the end users experience any problems, they are solved.

Most new IT investments are evaluated by considering the pros against the cons but, only in rare cases, costs and benefits are identified and estimated. The existing IT systems are only evaluated when a problem occurs.

**Comparison of the companies**

The characteristics of the five case study companies are summarised in *Table 9*.

*Table 9. The five case study companies*

| | Rambøll | Cowi | NIRAS | Højgaard & Schultz | Troels Jørgensen A/S |
|---|---|---|---|---|---|
| Type of company | CE[1] | CE | CE | CO[2] | CO |
| Origin (year) | 1945 | 1930 | 1956 | 1918 | 1976 |
| Turnover in 1999/2000 (million DKK) | 1,206 | 1,354.1 | 325.3 | 3,985.3 | 100 |
| No. of employees | 1,856 | 2,148 | >600 | 3,126 | 275 |
| Geographical span | Denmark & International | Denmark & International | Denmark & International | Denmark & International | Local |
| IT investment (as percentage of turnover in 1999/2000) | 4.1 | 7.4 | 0.4 | 0.34 | 0.25 |

[1]CE ~ Consulting Engineer
[2]CO ~ Contractor

Rambøll and Cowi are, in some of their characteristics, similar. They are among the three largest consulting engineers in Denmark and are regarded as large even when considering other internationally competing consulting engineers. The last consulting engineer involved in the case studies is, even though it is the fourth largest in Denmark, not as big when compared to Rambøll and Cowi. Højgaard & Schultz is the largest of the case study companies especially when compared to Troels Jørgensen A/S (this is primarily because the scope of their business activities is different).

Most of the case study companies are investing in IT systems in order to increase the efficiency of their existing business activities, whereas almost none of them are using IT systems which are focused on providing unique services which can be used to differentiate themselves.

The maturity of the case study companies' IT evaluation practice differs but can generally be characterised as relying on methods, that are using informal IT evaluation procedures, but when evaluating large IT investments, one of the case study company used methods that are characterised as formal IT evaluation procedures. This is not unlike the tendency as identified in the survey described in chapter 4.

Overall it is argued that the case study companies represent a range of different characteristics within the group of consulting engineers and contractors.

### 5.4.2 The IT evaluation

The focus is, in this section, on why the company wants to evaluate the IT investment and identification of the requirements for the IT evaluation.

The primary source of these descriptions is a series of interviews completed with the purpose of describing the IT evaluation and the IT investment (a summary of these interviews can be seen in the following Appendices B2, C2, C4, D3, E2 and F3).

**Rambøll**

Rambøll was, in spring 2000, developing a CAD action plan in which the primary objectives were mainly to provide all Rambøll's employees with access to a CAD system and, secondly, to upgrade AutoCAD 14 to AutoCAD 2000. The decision on upgrading their AutoCAD application was already made, but the question of whether the IT investment should be postponed for a period (for about six months) was still unclear. Because of this situation the CAD manager from the division *Building and Industry* wanted to identify and quantify the cost and benefits using two scenarios.

*Scenario 1:*
The upgrade of AutoCAD would be initiated immediately (spring 2000). All AutoCAD 14 applications in the division Building and Industry would be upgraded to AutoCAD 2000.

*Scenario 2:*
The upgrade of AutoCAD would be initiated in autumn 2000. All AutoCAD 14 applications in the division Building and Industry would be upgraded to AutoCAD 2000.

The short time difference between the scenarios implied that the time available for completing the IT evaluation was sparse as a quick decision was needed. This turned out to be a problem because the case study (and therefore the IT evaluation) could not be completed within the necessary time limit. The decision to immediately upgrade the AutoCAD application was therefore taken during the case study.

The purpose of completing the IT evaluation was therefore changed to focus on identifying and estimating the costs and benefits of upgrading to AutoCAD 2000 compared to not upgrading. This was because the CAD manager was interested in identifying whether the IT investment was worth the resources (even though the decision on upgrading was already made).

More precisely, what has been evaluated in this case study is the improvement of CAD drawing production by using AutoCAD 2000 compared to using AutoCAD 14, if the same employees had upgraded their AutoCAD application. In this sense it is not only the AutoCAD application's performance, but also the employees usage of the IT application, that is evaluated.

This decision has several implications. Firstly, all the benefits gained by using AutoCAD 14, which are also gained by using AutoCAD 2000, will not be included in the IT evaluation. This means that the IT evaluation will not generate any conclusions about using AutoCAD applications in general. Secondly, the improvements in performance by using AutoCAD 2000 will only provide a benefit if the employees using the applications are skilled enough and capable of benefitting from the performance improvements. It is therefore necessary to include some considerations about the end-users skills and capabilities in the IT evaluation.

Another purpose stated for the evaluation of the IT investment is that the implementation of AutoCAD 2000 in the division Building and Industry will be used as a pilot project in order to identify the best approach when the other divisions upgrade their CAD systems (two CAD systems are predominantly used in the company; MicroStation and AutoCAD).

The primary output from the IT evaluation should express whether or not the upgrade of AutoCAD 14 is worthwhile and should consider the different types of benefit achieved from the IT investment.

The IT evaluation was primarily completed by the CAD manager and the author of the present dissertation. However during the case study some of the temporary results from the methods were shown to other colleagues of the IT manager for comment.

**Cowi**

The board of directors in Cowi decided, in 1996-97, to implement three major IT systems with the aim of supporting the core activities in Cowi and thereby enhancing the strategic position of the company in the future. The three major IT systems were identified as a new economy system, a groupware system and an electronic document management system (EDMS). Later on the actual IT systems were determined to be respectively: SAP, Microsoft Exchange/Outlook and Documentum WorkSpace (DWS).

The EDMS was identified as an important IT investment because the company's core competency is knowledge and therefore the company needs to be able to manage its information and knowledge and, in this case, the electronic documents produced. The need for an electronic document management system was identified through one of Cowi's projects in 1996 with the customer Maersk. On one of the offshore projects Maersk required Cowi to provide them with a drawing list with version registering from time to time, which at that time could only be produced manually. Producing the drawing list required a significant amount of manual labour and was therefore relatively expensive for Cowi.

DWS was chosen through an extensive examination of currently available electronic document management systems. In the beginning 250 EDMS systems were identified although a closer examination limited it to 15 potential IT systems. This was through a detailed examination limited to 6 potential electronic document management systems where DWS was chosen as the most promising one.

The decision leading to the evaluation of DWS arose because Cowi's board of directors decided that the three core IT systems: SAP, Microsoft Exchange/Outlook and Documentum WorkSpace, should be evaluated (more precisely: measured) at regular intervals so the financial value could be identified. This decision was a part of a greater project called Project Profitability where the main purpose was to identify the efficiency gains of a series of projects that should increase the company's productivity.

The reason why the board of directors in Cowi wants to evaluate DWS is to identify, and especially measure, the economic benefits of using the IT system. This is primarily done with a focus on the company's production and management of CAD drawings. The IT evaluation will provide the board of directors with some inputs on whether DWS was indeed a profitable IT investment.

The IT evaluation focuses on evaluating the impact on Cowi's production and management of CAD drawings by implementing DWS compared to not implementing it. Not implementing DWS means continuing the current working procedures.

The desired output of the IT evaluation of DWS is a measurement plan for how to monitor and measure the economic benefits. The measurement plan will enable Cowi to identify the profitability of DWS.

The organisation behind the project 'Reap IT benefits' consists of two groups; the project group and the task group. The project group, which evaluates DWS, consists of a project leader[11], the project leader of DWS[12], an EDMS expert[13] and an end-user[14]. The task group, which focuses on evaluating the project group's progress and results, consists of a senior manager, the project leader of DWS and the project leader of "Reap IT benefits" and a few others.

**NIRAS**

The background for the company's interest in a projectweb can be traced back to the PPB competition in which a consortium called Habitat was involved (NIRAS was a partner in this consortium). A projectweb was used with some success and this raised the question in the executive committee whether NIRAS should use it as well in their other building projects. The executive committee decided therefore, in year 2000, that some money in the IT budget should be allocated to implement a projectweb in NIRAS.

The company was in a situation where it was about to choose a strategy for how to implement a projectweb in their future building projects. Different possible alternatives were identified (these are described in a later section). The purpose of the IT evaluation was therefore to evaluate which of the possible strategies they should choose.

The output of the IT evaluation should therefore express the different alternatives' usefulness to the company and ultimately lead to the identification of the best projectweb strategy.

The primary contact person in the case study was an employee who also worked as an internal consultant in matters where important decisions about the company's IT usage were the issue.

**Højgaard & Schultz**

The decision leading to the evaluation of two different projectwebs (these are described in details in a later section) arose because the director of the Building division decided to identify the best projectweb for their future building projects. Some experiences in using projectwebs had already been achieved through the usage of the two projectwebs on the building of their own headquarters and in the PPU consortium (another of the winning consortiums in the PPB competition).

Only one projectweb application will be implemented on future building projects, and they will therefore have to identify the best and most suitable one. Choosing only one projectweb might give them some advantages because they would otherwise not be fully able to standardise their use of a projectweb and they would, at the same time, present a desirable image to their customers.

[11]The project leader is normally working in Kolding as the department leader for the Environmental department
[12] The project leader for Documentum's implementation is working in the IT department
[13] The EDMS expert is working for the IT & Management department and has experience in IT evaluation and EDMS systems
[14] This person is an end-user of Documentum and is working in Cowi's division "Road design department"

The IT evaluation focuses on the impact on H&S's electronic document management by implementing a projectweb compared to not implementing one. Not implementing a projectweb means continuing the current working procedures and business activities that are focused on electronic document management and exchange.

The desired output of the IT evaluation is identifying which projectweb is the best for H&S to use on their future building projects. This means identifying the most useful for H&S by using both of the evaluated projectwebs.

The IT evaluation was mainly completed through collaboration between a member of the Technical department (one of the divisions in H&S) and the author. The participating employee from H&S has delivered all the data used in the methods.

**Troels Jørgensen A/S**

TJAS has, in previous years, been expanding its business by, for example, taking over a pre-fabricated element factory. The expansion of the business has made it necessary to establish several administrative offices near to the new acquisitions. This has led to an increased workload for the administrative staff because the coordination between the offices required an increasing amount of time. It was decided to implement a CITRIX application (for a more detailed explanation of the IT system see the later section describing the IT investment) that ideally would reduce the pressure on the administrative staff. The company was unsure what the actual impact of using a CITRIX application would be as it is a relatively immature technology. The purpose of the IT evaluation was therefore to evaluate the impact on the company of using a CITRIX application.

More precisely, what has been evaluated in this case study, is the improved usage of the company's IT applications especially the administrative staff's usage of the economy system compared to continuing using the existing working procedures. It is therefore not only the CITRIX application's performance, but also the employees' usage, that is evaluated.

Completing the IT evaluation should provide output that express the benefits (both financial and non-financial) from using the CITRIX application, primarily by the administrative staff.

The IT evaluation was completed in collaboration with the IT manager and his right-hand employee. All the data used in the IT evaluation was collected through meetings and interviews with employees from TJAS.

**Comparison of the IT evaluations**

The characteristics of the five IT evaluations are summarised and shown in *Table 10*.

*Table 10. The five IT evaluations*

| | Rambøll | Cowi | NIRAS | Højgaard & Schultz | Troels Jørgensen A/S |
|---|---|---|---|---|---|
| Purpose of IT evaluation | Evaluate costs and benefits of AutoCAD 2000 | Establish a monitoring plan for the usage of DWS | Identify the best projectweb strategy | Identify best projectweb | Evaluate impact of from using CITRIX |
| IT evaluation criteria | Financial | Financial Strategic Effectiveness of use | Financial Requirements | Financial Competitive Strategic | Financial |
| Format of output | Financial Qualitative | Financial | Financial Requirements | Financial | Financial |
| IT evaluation champions | IT manager | Various levels | Internal IT consultant | IT expert | IT managers |

The five case studies represent several aspects of a range of different IT evaluations. For example two of the case studies focus on evaluating the impact from the IT investment, two are focused on identifying the best IT investment, and one on measuring the financial benefits.

It is notable that all five case studies are interested in evaluating the IT investments' financial value, which could be due to the fact that most competition in the construction industry is cost oriented.

The five case studies will together provide a good basis for the usage of the four IT evaluation methods as they are representing different types of IT evaluations.

### 5.4.3 The evaluated IT investments

The evaluated IT investments in the case study companies are briefly described with regard to their general characteristics and objectives, in this section.

The descriptions in this section are partly based on a series of interviews (see Appendices B2, C2, C4, D3, E2 and F3) and partly on documents, that describe the IT system, retrieved from the Internet.

**Rambøll**

The IT investment evaluated in Rambøll, is the upgrade of the existing licences for AutoCAD 14 to AutoCAD 2000 in the division called Building and Industry.

***Description of AutoCAD 2000***

AutoCAD 2000 is a CAD system developed by AutoDesk that was released in year 2000. It is a customisable, 2D and 3D design and drafting environment and toolset. Architects, engineers, draftspersons, and design-related professionals can use it to create, view, manage, plot and output, share, and reuse technical drawings.

This version, compared to AutoCAD 14, has been improved with about 400 new functionalities. A few of them are listed below:

- Multiple drawings open
- Improved file navigation
- Improved reuse of old drawings
- Ease of plotting

AutoCAD applications are not designed specifically to fulfil the needs of the construction industry but provide several functionalities the construction industry can benefit from. AutoCAD products can, however, be enhanced by the IT application, Point, which is addressed specifically to fulfil the needs of the construction industry. The Point application and the other applications used by Rambøll can be characterised as enhancements of AutoCAD 2000, and are not included in this IT evaluation. This is mainly because the functionalities provided by these applications do not radically change the usage of AutoCAD 2000 compared to the usage of AutoCAD 14. In practice, however, these applications have to be upgraded as well.

***Objectives for the IT investment***

Ever since AutoDesk released AutoCAD 2000 there has been a growing need for it in Rambøll. Four major needs were identified:

- Rambøll's collaboration partners (both suppliers and customers) are beginning to demand AutoCAD 2000 drawings
- The suppliers and collaboration partners are now sending AutoCAD 2000 drawings to Rambøll
- AutoCAD 2000 has incorporated about 400 new functionalities compared to AutoCAD 14. A few of these are:
- Several drawings opened at the same time
- Smarter plots
- The employees expect to work on the newest available version

Basically the objectives for using AutoCAD 2000 are not financially motivated but have arisen because of an increasing demand from outside the company. The economic benefits from the IT investment are, by the company, not considered significant because the changes made in the software are minor.

The IT investment is characterised as having an impact on the efficiency of the production of CAD drawings. It is, in other words, an IT system that sustains and improves the existing efficiency of CAD drawing production in the division.

**Cowi**

In this case study the IT investment evaluated is the implementation and usage of Documentum WorkSpace in all of Cowi's departments in Denmark. DWS can be characterised as an EDMS system. In total 1050 licences have been bought.

***Description of Documentum WorkSpace***

The EDMS system, Documentum WorkSpace, was developed by an American company called Documentum. In Denmark TietoEnator Technology A/S has the rights to distribute the IT system. It is the intention that Cowi will upgrade this version to Documentum SmartSpace.

In order to support some of Cowi's existing requirements and procedures for the production and management of CAD drawings, the IT application has been expanded by implementing a few programmed enhancements done by Cowi themselves. An example of this is the support of the company's quality control procedures.

The heart of DWS is the Documentum DocPage Server, which is a database server that manages the electronic documents stored in the database. DWS requires one of the operating systems: Windows 95, Windows 3.1, NT Workstation 3.5.1 or 4.0. Currently Cowi has both Windows 95 and NT Workstation 4.0 as operating systems in Denmark.

Documentum has written in a pamphlet a short description of DWS as follows:

> DWS is a robust, powerful environment that provides the full complement of document management services to co-ordinators -- the users in your company who create and define the business policies or co-ordinate the document processes that drive your business. Co-ordinators can navigate a Docbase using WorkSpace or, through application integration, their familiar desktop applications.

DWS does increase both the efficiency and effectiveness of Cowi's existing document management procedures and activities. In order to ensure that DWS is capable of handling Cowi's CAD drawings (both Microstation and AutoCAD) a few extra IT applications have to be implemented as well. These are as follows:

- CADLink Designer
- CADLink Review
- Plotcenter

***Objectives for the IT investment***

The main objective of implementing DWS is to be able to control one of the core activities in Cowi, the CAD drawings. The following objectives were identified:

- Some working procedures and activities became too resource demanding if completed manually
- Increasing the efficiency of the production and management of CAD drawings
- Improving the quality of the production and management of CAD drawings
- Supporting and enhancing the quality management procedures used in Cowi
- Providing a better tool for exploiting the information and knowledge gained in earlier projects

The decision leading to the IT investment was taken at a strategic level and some of the objectives are strategic in character, but in general the IT investment is financially motivated. The economic benefits are considered, by the company, as an important aspect of the IT investment. The objective is not to change the ways in which things are conducted but is more focused on how to improve the efficiency of the existing procedures and activities.

DWS can be characterised as an IT investment that has impact on the working procedures and quality controls of the production and management of the company's CAD drawings. It is therefore an IT system that improves the existing efficiency and effectiveness of the production and management of CAD drawings.

## NIRAS

In the case study with NIRAS the IT investment evaluated was not a specific IT system but more an evaluation of the strategy for the company's usage of projectwebs.

### *Description of projectweb*

More than one projectweb was relevant to the company because the primary task was to identify which projectweb they should use on which building projects.

A projectweb is, in this context, defined as an IT system that enables an easier exchange of electronic documents and other information between the members of a building project. A project member can either be an NIRAS employee or an external person working for one of the collaboration partners.

Several alternatives were identified.

- **Leasing a projectweb (Application Service Provider)**
  The first potential alternative is leasing a projectweb from an external supplier. Examples of external suppliers are *www.projecthotel.dk* and *www.byggeweb.dk*. Both of these are Danish, whereas Citadon is an example of an American supplier.
- **Buying a number of licences for a standard system**
  The second alternative is buying a number of licences of a standard system, which has a web-based functionality, as part of the general document management concept. An example on such an IT system is Quickplace 2.
- **Developing ones' own projectweb**
  The third alternative is developing the company's own projectweb. There is, in this alternative, no thought of developing an advanced projectweb, but rather a solution that enables the end users to up- and down-load electronic documents.
- **Usage of collaboration partners' projectweb**
  The last alternative is using the collaboration partners' projectweb. This solution focuses on not investing money in projectwebs but using the collaboration partners' projectwebs.

### *Objectives for the IT investment*

In general this IT investment focuses on improving the exchange of electronic documents in building projects. This means that the IT investment's primary impact is increasing the efficiency of the existing working procedures related to the electronic document exchange. The aim is not a advanced solution to provide advanced functionalities.

## Højgaard & Schultz

The case study completed at Højgaard & Schultz focused on evaluating two different projectwebs. The first projectweb is developed in-house by H&S in collaboration with Rambøll and Arkitektgruppen i Aarhus (an architect), all of whom are working together in the consortium called PPU. This projectweb developed in-house is, in the rest of the thesis, abbreviated to IHD. The second projectweb evaluated is called ProjectNet and is leased from an American company called Citadon.

### *Description of projectwebs*

The two different projectwebs are described in the following.

**In-house developed projectweb (IHD)**

IHD is developed by PPU itself. The actual development has been completed by three companies, who together comprised the PPU consortium.

It was developed during the period from 1995 to 2000 and has, in that period, undergone significant changes. The changes made in these years are, however, not the focus of this report and only the final version is described in this section.

IHD is an Internet web server with a very simple IT application that is able to manage and store the electronic documents uploaded. The structure of the directories and therefore the documents has to be defined beforehand and it may require considerable resources to ensure that the documents are stored in the correct locations.

The following functionalities are available in this IT system.

- Upload/download of electronic documents (CAD drawings, spreadsheets, texts etc.)
- Search abilities (metadata, filenames etc.)
- Logging of projectweb usage
- Administration of user rights (in part)

**ProjectNet**

Citadon, an American company, today distributes ProjectNet. In general it can be characterised as a project management tool in which there is an opportunity for exchanging electronic documents. It is an on-line web server that is accessible through the Internet if you have a user ID and password.

ProjectNet offers the following functionalities:

- Upload/download of electronic documents (CAD drawings, spreadsheets, texts etc.)
- Automatic handling of CAD drawings reference files
- Compression/decompression of uploaded/downloaded documents
- Notification of new relevant documents
- Calendar facilities (this can be synchronised with PDAs)
- Search abilities (full text, metadata, filenames etc.)
- Backup facilities
- Logging of projectweb usage
- Administration of user rights

The following description of ProjectNet is provided by Citadon on their homepage:

> The ProjectNet solution is currently offered as two components
>
> ProjectNet Process Internet-based, mission-critical, and scalable, ProjectNet Process's data-centric architecture is the perfect solution for managing multi-phase projects, enterprise engagements, and diverse portfolios of projects. In these types of situations, lack of visibility into a project's status or cumbersome coordination are often impediments to smooth execution. Citadon answers these problems by creating a rich store of knowledge for higher process efficiency.
>
> ProjectNet Process uses Citadon's flexible business process management system (BPM), enabling team members to manage projects utilizing their most efficient and effective business practices, thereby increasing their level of success. ProjectNet Process is the perfect solution for managing large, complex, multi-phase construction projects.
>
> ProjectNet Docs is a fast and powerful way to meet your team's goals, eliminate delays, reduce costs, improve accountability, and deliver results. Whether you're working in the same office or on different continents, you can setup

> and begin managing new projects quickly and efficiently. With a single login for members that provides instant access to all of your projects, ProjectNet Docs helps you and your team accelerate the review and decision-making process.
>
> ProjectNet Docs delivers industrial-strength document management and collaboration to the entire project team, allowing them to share and collaborate on project related documents, as well as being able to route them to the right persons for action and followup. Comprehensive and complete, this document management and collaboration solution provides access to your project materials and communications, such as design drawings and specifications, in a secure online environment. View and work with over 250 file types, including CAD documents and spreadsheets, and synch tasks and action items to Microsoft Outlook and PDAs such as Palms and Windows CE devices.
>
> Taken from Citadon's own homepage February 2001

### *Objectives for the IT investment*

The main objective of using a projectweb is to increase the efficiency of the external exchange of electronic documents. The following objectives were identified:

- Continue using a projectweb in building projects where H&S is a main contractor
- Increasing the efficiency of exchanging the electronic documents
- Sustain H&S's position as the leading contractor in Denmark
- Explore the possibilities of the Internet

The development board of H&S (a part of the strategic level) decided that the IT investment should be implemented and therefore some of the objectives are strategic in character. The IT investment is, however, also considered as financially motivated because the economic benefits are considered as an important aspect of using a projectweb. The objective is partly to innovate the exchange and management of electronic documents between the collaboration partners and partly to reduce the cost of existing activities.

The two tested projectwebs are very different in some respects. IHD is mostly focused on replacing existing working procedures with some more efficient ones. The main characteristic of IHD is therefore on automating the existing working procedures.

ProjectNet can be characterised as increasing both the efficiency and the effectiveness of the existing working procedures. The increase in efficiency is because it focuses on automating the existing working procedures simply by requiring less manual work and in a faster way. The increase in effectiveness is because it enables some of the working procedures to be done differently (and with a better result) than before.

## Troels Jørgensen A/S

The case study of Troels Jørgensen A/S (abbreviated to TJAS) focuses on an IT investment called CITRIX MetaFrame for a Windows 2000 terminal server. The IT investment enables the administrative staff access to the company's economy system, Concorde XAL, no matter from where (there are a few restrictions) or whenever they have the need to do this. CITRIX also enables the administrative staff to get access to the most up to date economic data.

### *Description of CITRIX*

The CITRIX application is developed by CITRIX Systems Inc. an American software company. It was released in 1990 and since then the company has been growing very fast. The version in focus in this IT evaluation is called CITRIX MetaFrame 1.8 Windows 2000.

In short, CITRIX enables a concept called server-based computing meaning that IT applications are deployed, managed, supported and executed completely on the server. In other words the end users are, with CITRIX, able to get access to all (depending on the company policy) of the company's IT applications no matter where or when they want to execute them.

Server-based computing comprises three important aspects:

- **Multi-user operating system**
  Allowing several end-users concurrently to run IT applications in a separate and secure way.
- **Remote presentation services architecture**
  This is based on an efficient deployment of the bandwidth of the communication lines because it is only the changes in the interface (e.g. mouse movements, keystrokes and screen updates) that occupy the communication lines.
- **Centralised application and client management**
  These enable the company to overcome the deployment challenges of the IT applications' management, access, performance and security.

Some features of CITRIX MetaFrame are listed in the following (the list is not complete):

- Enterprise scalability
- Extensive connectivity
- Flexible management and administration
- Enhanced security features

The end-users' hardware requirements are minor (the extreme is a thin client), and the most significant requirement is an Internet connection (minimum ISDN).

***Objectives for the IT investment***

In the company for the last few years there has been a growing need to centralise the economy data produced throughout the company's different sub-companies and offices. The available technology has so far not been able to provide a suitable solution to the problem, but the company has, in CITRIX, identified a useful tool for solving it.

The following main objectives were identified:

- Higher security of important economic data from various sub-companies and offices.
- Geographically spread offices and end-users can get access to, and store, important data and execute the company's IT applications.
- The maintenance costs of software and hardware will be reduced.

The major objectives are not primarily of a financial character. Instead higher capacity for the administrative staff, and an increased security of confidential data (the economic data), are some of the objectives in implementing CITRIX.

The main focus of TJAS's usage of a CITRIX application can be characterised as increasing the efficiency and effectiveness of especially the administrative working procedures. The increase in efficiency is because of the faster (and better) execution of some of the existing administrative tasks, and the increase in effectiveness is because of the availability of completing some of the working activities differently.

## Comparing the case study IT investments

A few characteristics of the evaluated IT investment can be used to compare the case studies.

*Table 11. Characteristics of the case study IT investments*

| | Rambøll | Cowi | NIRAS | Højgaard & Schultz | Troels Jørgensen A/S |
|---|---|---|---|---|---|
| Type of IT investment | Automation | Direct Value Added/Strategic systems | Inter-organisational systems | Inter-organisational systems | Infrastructure |
| Main impact[15] | Automation | Information | Automation | Information | Information |
| Location of main impact | CAD drawing production | Production and management of CAD drawings | Document exchange | Document exchange and project management | Company accountancy |
| Affected end-users | ▪ CAD operators<br>▪ Engineers | ▪ CAD operators<br>▪ Engineers<br>▪ Project members | ▪ Project leaders<br>▪ Project members | ▪ Project leaders<br>▪ Project members | ▪ Administrative staff<br>▪ Conductors |
| Stage of IT investment | Upgrade or abandon IT system | Implement IT system | Consider new IT investment | Decide IT system | Implement IT system |

The five IT investments in the case studies are all relevant for companies from the construction industry because they represent IT investments that are likely to be proposed and evaluated in these companies.

Different types of IT investments are represented in the case studies, ranging from automation to strategic systems. The evaluated IT investments' main impacts on the company are all identified as automation or information. None of the IT investments evaluated are categorised as having a major impact on transformation of the company's business activities. This can perhaps be explained by the construction industry being a well defined business area in which the competitors are changing only a little.

The two large consultants are investing in IT systems that mainly impact CAD drawing production. This might enable some comparative possibilities between these case studies. Another similarity can be identified for NIRAS and H&S who both invest in IT systems defined as projectwebs.

The group of end users changes, largely depending on the location of the main impact. In all of the IT investments there have been several groups of end-users. In the two case studies on projectwebs the groups of end users are found to be similar.

[15] The IT investment's main impact is defined by using the terminology proposed by (Remenyi, Money, & Twite 1995) (see also chapter 2)

Lastly the case studies' IT investments represent different stages of the life-cycle. Four stages are represented in the case studies. It is not so good that none of the IT investments are evaluated at the usage stage, because it is after all in this stage that the actual benefits are achieved.

In general the case study IT investments have different characteristics but there are also some similarities.

## *5.5 Summary*

In this chapter five case studies have been presented by describing three primary aspects; the company, the IT evaluation and the evaluated IT investment.

The five selected case studies represent three consulting engineers and two contractors, and are as follows:

| Company name | Company type | IT investment |
|---|---|---|
| Rambøll | Consulting engineer | AutoCAD 2000 |
| Cowi | Consulting engineer | Documentum Workspace |
| NIRAS | Consulting engineer | Projectweb strategy |
| Højgaard & Schultz | Contractor | Projectweb solution |
| Troels Jørgensen A/S. | Contractor | CITRIX |

The case studies represent a range of different IT evaluations and are therefore considered as providing useful data for the development of the framework.

# Chapter 6: Output from the four IT evaluation methods

This chapter contains a presentation of the output from using the four selected IT evaluation methods (as described in chapter 3) on the five case studies.

Firstly, the general assumptions and limitations needed in order to complete the four methods, are described. Secondly, each case study is presented with regard to the special assumptions and limitations defined and the output provided by the four methods. The directly derivable conclusions on the basis of the output are discussed in the last part.

This chapter fulfils two purposes. First, it describes the output from the four methods used on five different IT investments that are considered as relevant to companies from the construction industry (see also the description of the case study objectives in chapter 5). Other companies might be able to learn from and use the output and experience described in this chapter when completing their own evaluations of one of the evaluated IT investments. Second, analysing the output from the four methods can be used as a part of identifying the methods' usability in different IT evaluations.

## *6.1 General assumptions*

This section describes the assumptions made in all five case studies in order to be able to complete the four IT evaluation methods. The assumptions made are either considered as necessary because the IT investment otherwise would be too difficult to evaluate (the level of uncertainties will be to high), or because some of the methods require it.

The first assumption has a significant impact on the output of the methods. The IT investments' lifetime has to be estimated in order to be able to estimate its total cash flow. The lifetime of the IT investments is defined as the period in which the IT investment is used in the company without the need for major additional investments.

Changing the expected lifetime of the IT investment can change the output of some of the methods especially the financial and quantitative methods. Reducing the lifetime may change the ratio between costs and benefits and thereby make it less profitable. This will, however, also reduce the uncertainties about the future use of the IT investment. Increasing the lifetime of the IT investment may also change the ratio between costs and benefits. The accuracy of the cost and benefit estimates might be worsened because, the longer the lifetime used, the less predictable the cash flow might be.

The lifetime of the IT investments in the case studies needs to be determined for each IT investment. The first assumption in the case studies is therefore focused on determining the IT investment's lifetime.

The second assumption focuses on the end users' abilities in using the proposed IT investment. It is, in all five case studies, assumed that all the end users will either upgrade their knowledge of, and skills in using, the new functionalities provided by the IT investment, or that they already possess the necessary knowledge and skills. A certain amount of money is, for most of the case studies, allocated for this purpose in the cost estimate.

The consequence, if the assumption is not valid, would be that some of the identified benefits might not accrue to the company owing to a less efficient usage of the IT investment. An even worse situation could be a loss of productivity because the end users experience the IT investment as a constraint in their working procedures and will therefore avoid using the IT investment.

The third assumption made in some of the case studies is that benefits, that are identified as resulting in time-savings, are directly associated with cost savings. These types of benefit can only be considered as cost-saving if the time saved for each end user is spent on other, at least equally valuable, activities. For these benefits it is therefore assumed that the time saved is actually spent on activities that are adding a value equal to the cost of the end-users' time and they can therefore be regarded as a benefit.

If this assumption is not true, it would, in the worst case, mean that the identified time-saving benefits would not be accrued to the company but to the end-users. Another problematic aspect of this assumption is that the time savings might not necessarily accrue to the company or the end-users, but to the customers as a result of reduced invoices. This case would, however, result in an increased competitive strength for the company.

The last assumption, used in the case studies, is considered as the broadest one. It is assumed that the competitive situation in the Danish construction industry is not significantly changed in the near future. The assumption is needed because a significant change in the competitive situation might change the company's strategic plans, and that might have a major implication for the decisions on the evaluated IT investment.

Significant changes in the competitive situation may result in some unexpected changes in a company's strategic plans. An example of this could be delaying an IT investment until the situation is more stable.

## *6.2 Rambøll*

The first case study described is with Rambøll.

Firstly, the assumptions and limitations made in the case study are described and, secondly, the output from each method are presented on the basis of the evaluation of the upgrade to AutoCAD 2000 and, lastly, some comments on the methods' output are given.

### 6.2.1 Assumptions and limitations

The first assumption has a significant impact on the output of the methods. The lifetime for AutoCAD 2000 is estimated as two years because it is likely that AutoDesk will, by the end of that period, release a newer version.

The second assumption is that the usage of AutoCAD 2000 will be accepted as one of the standard CAD systems in the construction industry. This implies that an increasing number of companies will be using AutoCAD 2000 in the following two years. The result of the increasing usage is that more CAD drawings will be received and sent by Rambøll in that format.

If AutoCAD 2000 is not accepted as one of the standard CAD systems in the construction industry then many of the benefits identified and estimated would give a wrong picture of the IT investment. It may also constrain the company in collaborating with some of its partners and result in a loss of projects.

A part of the current effectiveness of Rambøll's CAD drawing production is based on the CAD standards and CAD manual used. It is therefore assumed that both of these are upgraded so that they take advantage of AutoCAD 2000 instead of constraining the CAD drawing production.

Not upgrading the CAD standards and CAD manual could result in an inefficient use of AutoCAD 2000 and may therefore limit the benefits achieved. It may furthermore be seen as a hindrance to the end-users if the CAD standards and CAD manual require working procedures or "products" not supported by AutoCAD 2000.

Once AutoCAD 2000 is implemented it is assumed that the end users' productivity will be reduced for a period. The end users' productivity will, however, after a certain period, reach a higher level than the situation where the end users continue using AutoCAD 14. The higher level of productivity will be reached when the end users become familiar with the new version of AutoCAD and they have adjusted their working procedures so that the advantages of AutoCAD 2000 are exploited. The reduction of end user productivity is included in the cost estimates for the IT investment.

The length of the reduced end user productivity and the impact of such a reduction might be a little uncertain because this assumption depends on some of the other assumptions, for example the employees' knowledge and skills in using AutoCAD 2000. If the reduction of end user productivity is higher, or the period is longer than estimated, then the ratio between benefits and costs will be lower. In case of the opposite the result will be reversed.

The two major limitations made in the case study are:

Even though the CAD action plan focuses on providing all Rambøll's employees with access to a CAD system it is only the upgrade of AutoCAD 14 to AutoCAD 2000 to all the existing CAD end-users in the division *Building and industry* included in this IT evaluation. This choice of IT evaluation focus does not indicate that providing all the employees in Rambøll with access to a CAD system is considered as uninteresting. The choice was made because this would prove to be an IT evaluation many companies from the construction industry are likely to experience themselves, and would therefore be useful to many companies instead of a few.

The IT evaluation focuses on upgrading AutoCAD from version 14 to 2000 which means, as stated earlier, that the results from the methods cannot be used to justify whether a CAD system is worth the resources or not.

### 6.2.2 Net Present Value

*Figure 25* shows the discounted cash flow for upgrading to AutoCAD 2000. A more detailed insight into the calculation of the net present value can be found in the Appendices B4, B5 and B6.

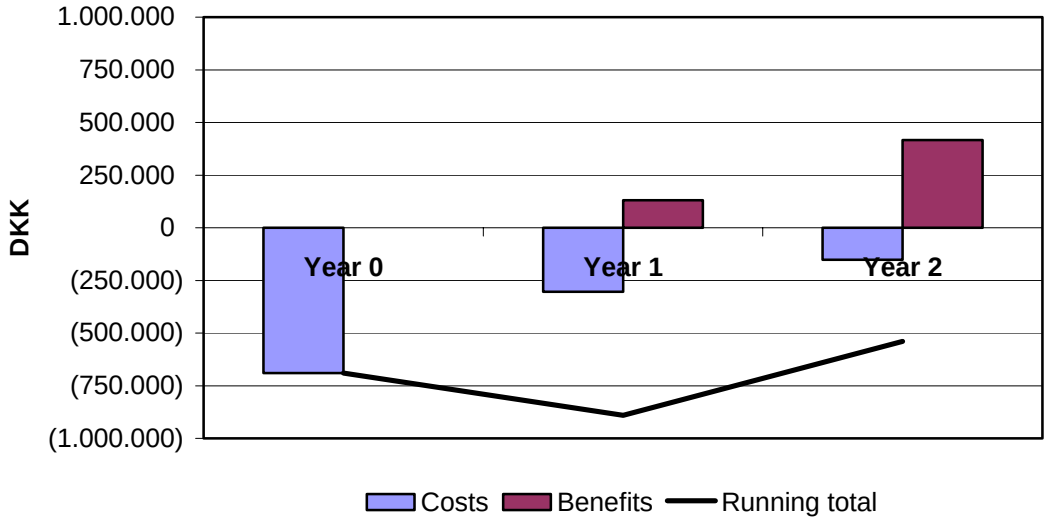



*Figure 25. Discounted cash flow for upgrading to AutoCAD 2000*

The net present value of upgrading to AutoCAD 2000 was calculated as **–599,263 DKK**. The major reasons for the negative output are the start-up costs of the IT investment and the fact that the running costs in year 1 are higher than the received benefits for this year.

In the second year the benefits achieved are strongly influenced by the benefit *Reduced upgrading costs* (see Appendix B5). The benefit is achieved because next time Rambøll upgrades AutoCAD they will have to buy new licences if they continue using AutoCAD 14. The reason for this is that it will, at that time, not be possible to upgrade AutoCAD if the version span is larger than 1, without buying new licences.

On the other hand if Rambøll upgrades their AutoCAD licences now, they can, when AutoDesk release the next version, be content with the cost of upgrading which is significantly cheaper than buying a new licence.

Viewing the results from the method, it can be concluded that the IT investment should not be approved on the basis of NPV. Upgrading to AutoCAD 2000 would, according to this method, mean a loss of money of approximately 600,000 DKK and this is, of course, not satisfactory from a financial point of view.

### 6.2.3 Measuring the Benefits of IT Innovation

*Table 12* shows the summarised output from MBITI (see also Appendix B7).

*Table 12. "Presentation" sheet from MBITI*

| Type of Benefits | Expected Benefits | Measured Benefits |
|---|---|---|
| Efficiency Benefits - Quantifiable and Financial | Total forecast monetary value<br>460.000 DKK | Total realised monetary Value |
| Effectiveness Benefits - Quantifiable but Non-Financial | Total forecast score / 100<br>None identified | Total realised score /100 |
| Business Performance Benefits - Non-Quantifiable and Non-Financial | ▪ Strategic planning C<br>▪ Improved company image B<br>▪ Better integration with other IT systems B<br>▪ Requisite application for other IT applications A<br>▪ New functionalities A<br>▪ Better collaboration with partners B<br>▪ Improved employee satisfaction A<br>▪ Growth in usage A | |

The table shows financially measurable benefits worth 460.000 DKK. The output is the benefits achieved during the two year life of the IT investment compared to continuing using AutoCAD 14.

The second of the benefit tables (effectiveness) corresponds to the results in the middle section of *Table 12*. None of the identified benefits could be categorised as effectiveness benefits so therefore this result is not revealing much. In the first attempt to identify and categorise the benefits one benefit was categorised as an effectiveness benefit but it was, later in the IT evaluation, changed to a performance benefit primarily because it was too difficult to estimate the necessary attributes.

The last row in *Table 12* shows the identified performance benefits and their ratings. 8 performance benefits were identified. The benefit *Improved employee satisfaction* was, in the first attempt, categorised as an effectiveness benefit because of its apparent measurability. Four of the performance benefits were judged as being very significant (rated as A), three of them were rated as being significant (B), one was rated as being moderate (C) and none of them were judged as low (D).

Looking at *Table 12* it can be concluded that the performance benefits dominate the output of the method. The value of efficiency benefits is difficult to judge considering that the costs are not included. No effectiveness benefits were identified primarily because of the difficulties in identifying benefits that belong to this category. The output of the method shows a positive effect on the company and would therefore, without further considerations, most likely be approved.

### 6.2.4 Information Economics

The following diagram shows the output sheet from IE. A more detailed description of how the output were derived can be found in Appendix B8.

| | ROI | SM | CA | MI | CR | OR | SA | DU | TU | IR |
|---|---|---|---|---|---|---|---|---|---|---|
| factor | + | + | + | + | + | - | + | - | - | - |
| **Business Domain** | 1 | 3 | 2 | 0 | 2 | 0 | | | | |
| **Technology Domain** | | | | | | | 5 | 1 | 1 | 0 |
| Weight distribution | 5 | 3 | 4 | 3 | 2 | 5 | 3 | 2 | 2 | 3 |
| Sum | 5 | 9 | 8 | 0 | 4 | 0 | 15 | 2 | 2 | 0 |
| **Total Value** | **41** | out of | max. | 150 | and | min. | 0 | | | |
| **Total Risk** | **4** | out of | max. | 100 | and | min. | 0 | | | |

*Figure 26. Output sheet from IE*

*Figure 26* displays the mark given for each of the 10 factors, the estimate of the company weightings and the final scores.

*Strategic IS architecture* received the highest mark because the IT investment is considered as a part of the blueprint and is a prerequisite IT system for other IT systems in the company. At the other end of the scale the value factor *Management information* was given a mark of 0 because the IT investment is not considered as creating, providing or distributing management information.

The ROI factor has, because of a negative net cash flow, resulted in a ROI score of 21.7 % (50 % means break-even). The low ROI results in a mark of 1. The low ROI implies that the IT investment's costs (including both the investment costs and the running costs) are higher than the net benefits achieved throughout the IT investment's lifetime.

For the risk factors, two of them were given the best mark (which is 0). The factors are: *Project and organisational risk* and *IS infrastructure risk.* The marks were given because the IT investment creates a minimal risk for the company since they already use the previous version of AutoCAD. The changes made from AutoCAD 14 to version 2000 have not radically changed the IT system and therefore no upfront costs are anticipated. The worst mark given for one of the risk factors is 1. In total this results in a relatively low total risk.

Only 1 factor has been assigned a weighting of 5 and this is the ROI factor. The economic domain of IT investment is therefore regarded, by the company, as a very important factor when an IT investment is evaluated. None of the factors have been given a weighting of 0. This means that all 10 factors affect the final score.

For this IT investment the total value of upgrading AutoCAD 14 to AutoCAD 2000 is calculated as 41. Taken into consideration that the two extremes are 0 and 150, the total value is placed in the first third of the scale. Secondly the total risk is calculated to be 4. This is considered as very low and means that very little uncertainty or risk is associated with the implementation and usage of the IT investment. These values are not very informative in themselves but much information about the IT investment has been revealed through using the method.

Three significant aspects of the IT investment have been highlighted by using IE.

First the method provides an output stating that the IT investment is not profitable in terms of reaching break-even. This might however be strongly influenced by the short lifetime of the IT investment.

Second, three factors are identified as having a significant impact on the total value. These are in prioritised order:

- Strategic IS architecture (15)
- Strategic match (9)
- Competitive advantage (8)

Third, the method has identified that the technology factors do not have a large impact on the total risk. This means that the IT investment is largely considered as a technological benefit and that the technological risk and uncertainties from the IT investment are low.

Overall it can be concluded that the IT investment has a positive impact on the company. The impact is, however, not significant, for example the ROI factor is estimated to be low for the IT investment.

### 6.2.5 Critical Success Factors

The three interviewed stakeholders identified several different critical success factors in a series of short interviews. The list of critical success factors is derived on the basis of a series of interviews with relevant stakeholders in the IT investment (see Appendices B3 and B9). A combined list of critical success factors can also be found in Appendix B9 p. 34.

The identified critical success factors are, in the following, listed in random order:

- AutoCAD 2000's ability to function without problems in the current environment
- The CAD super-users approval of AutoCAD 2000 with regard to usability
- The commitment to use the AutoCAD 2000 is whole-hearted
- Ensuring the CAD drawing production standardisation is satisfied when AutoCAD 2000 is used
- Education of end-users (3)
- Consensus for upgrading to AutoCAD 2000 in all of the company's levels (2)
- Support to complete IT investment from the strategic level of the organisation (2)
- Planning the implementation and usage of the IT investment (2)
- Testing of AutoCAD 2000 in the real environment (2)
- Standardisation of CAD usage
- The upgrade to AutoCAD 2000 should be completed for all at one time (meaning no stepwise implementation)
- All current active CAD drawings have to be converted to the new format

Whenever a similar critical success factor is identified by several of the stakeholders the multiple number is written in brackets.

The two most important factors for ensuring success with AutoCAD 2000 were identified to be the following:

- Consensus at all company levels for upgrading to AutoCAD 2000
- Education of end users

A wide range of critical success factors has been identified from education of end users to strategic level approval to technical requirements. None of them is specifically referring to the economic impact of the IT investment.

The output provided by CSF are not useful for concluding whether the upgrade to AutoCAD 2000 should be approved or not. The difficulty in deriving a conclusion is because the factors cannot be considered as describing the actual IT investment but more as requirements that have to be fulfilled. All three stakeholders considered the upgrade of AutoCAD as a beneficial IT investment.

### 6.2.6 Comments on the methods' output

The three financially oriented methods have output that express a negative financial value. If the IT evaluation only focuses on the financial value, the IT investment would have to be rejected because it does not generate savings for the company.

However, considering other criteria than the financial value reveals another "picture". Both MBITI and IE highlight the non-economically measurable benefits as relevant for the IT evaluation. Whether the more in-depth output revealed would approve the IT investment cannot be determined because this is dependent on the company's approval criteria. The company's approval criteria have not been a part of the case studies and it can therefore not be concluded whether the IT investment would be approved. The output of MBITI and IE can be used to conclude that the IT investment is low to moderately desirable when considering the methods' output.

In total 10 different critical success factors were identified ranging from education of end-users to support of IT investment from the strategic level. They cannot be used to identify the cause and effect of the IT investment and cannot therefore be used to determine whether it is a good or bad IT investment. The method does however identify critical factors for having success with the IT investment, and these are considered as useful for increasing the success of the IT investment's daily management.

## *6.3 Cowi*

The second case study described is evaluating DWS (see chapter 5 for a more detailed description of the IT investment) in Cowi. The output from four methods are presented and a few general comments on the methods' output are enclosed.

### 6.3.1 Assumptions and limitations

The first assumption concerns the lifetime for the IT investment which is estimated as five years because it was judged as too difficult to predict the changes beyond a five years timescale. This assumption has a significant impact on the output of the methods, as Cowi might, in this case, decide to upgrade DWS to a newer version sooner or later than expected. This will probably have an important effect on the output from the financially oriented methods.

Some of the financial benefits are dependent upon the scale of usage, which makes it necessary to estimate the number of CAD projects during the five years. The number of projects, that produce CAD drawings, is assumed to increase slightly by 3.5% per year. The number of new projects that produce CAD drawings was, in 2000, estimated as 505. The estimation is made on the basis of the status of all Cowi's new projects that are registered in their economy system, SAP. The total number of new projects was 2205 and traditionally a third of these involve CAD drawings.

A change in the future number of this type of project will have a significant impact on the benefits achieved by using DWS. A decrease would naturally mean a decrease in the value of benefits and a more significant increase would likewise increase the value of benefits. Lastly a lack of new projects that produce CAD drawings, will mean a reduction of benefits.

All future projects, that in some degree involve CAD drawing production, are assumed to be created by, and managed in, DWS.

If this assumption were not true, then the benefits of the DWS naturally would not be achieved because only projects that produce CAD drawings by using DWS would generate the benefits identified. The consequence of using DWS on only a part of these projects could, in the worst case, mean a decrease in efficiency because the employees now have to use two different procedures for getting access to previous projects. In this case there is a danger that the end-users will find DWS a problematic IT system.

Two major limitations made in this IT evaluation are briefly described in the following.

In this IT evaluation a differentiation has been made between large and small projects that produce CAD drawings. A large project produces a large amount of CAD drawings compared to a small project and this makes some of the achievable benefits more significant in the large projects. The projects' sizes are defined by the value of the fee and are, for small projects, defined as up to 5 million DKK and, for large projects, as above 5 million DKK. Using this definition together with the assumption made above (3.5% increase of the projects) it is possible to estimate the number of future projects differentiating between large and small projects. This is shown in Table 13.

*Table 13. Number of large and small projects that produce CAD drawings in Cowi*

| Project size | Before Year 2000 (No.) | Year 1 (No.) | Year 2 (No.) | Year 3 (No.) | Year 4 (No.) | Year 5 (No.) |
|---|---|---|---|---|---|---|
| Large | 15 | 16 | 16 | 17 | 17 | 18 |
| Small | 490 | 507 | 525 | 543 | 562 | 582 |

From Table 13 it can be calculated that there are approximately 33 times as many small projects as large projects. This means that the large majority of projects, in relation to the CAD drawing production, are characterised as small projects.

DWS was originally developed with a focus on producing and managing electronic documents like texts, spreadsheets and e-mails, using MS Office products, whereas CAD drawings were not supported. With a few additional IT applications (as described in chapter 5) DWS is able to handle this as well. In this IT evaluation only the benefits in relation to the CAD drawing production have been included. This does not mean that other benefits are not anticipated from DWS with a focus on the production and management of other types of electronic document, but that they are just not included in this IT evaluation.

### 6.3.2 Net Present Value

The net present value of the IT investment was calculated as **–8,637,789 DKK** (using an interest rate of 4%). This is obviously a worrying output because of the high negative financial value (a more detailed overview of the calculations can be seen in the Appendices C5, C6, C7 and C8).

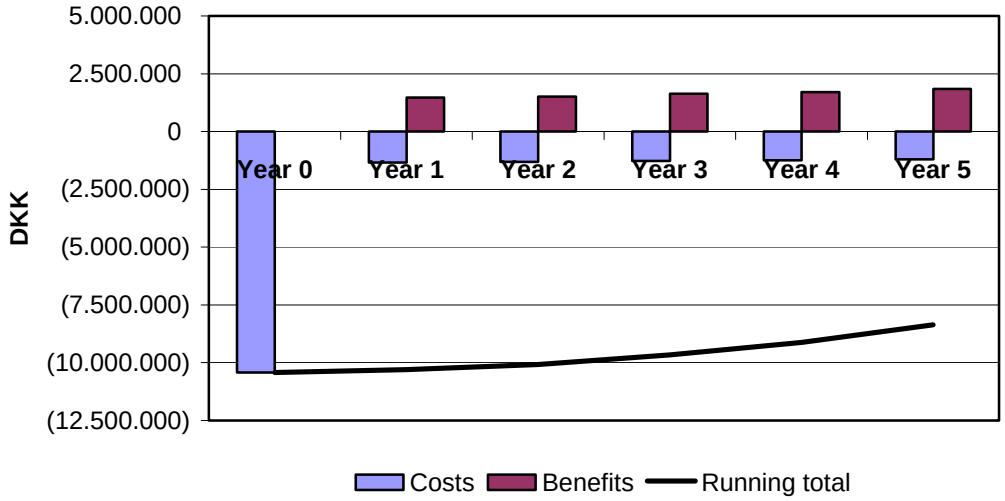



*Figure 27. Discounted cash flow for DWS*

The yearly discounted cash flow in *Figure 27* reveals, however, that the yearly benefits are numerically higher than the running costs. As the net benefit is increasing each year the net cash flow is reaching break-even but within a period significantly longer than the estimated five year lifetime. The primary reason why the net present value is negative is the start-up costs of the IT investment.

From the derived output it can be concluded that the IT investment should not be approved on the basis of NPV. Completing the IT investment would, according to this method, mean a loss of money of 8,637,789 DKK over a five-year period (measured in present value).

### 6.3.3 Measuring the Benefits of IT Innovation

The following table shows the summarised output from MBITI (see Appendix C9 further information).

*Table 14. "Presentation" sheet from MBITI*

| Type of Benefits | Expected Benefits | Measured Benefits |
|---|---|---|
| Efficiency Benefits - Quantifiable and Financial | Total forecast monetary value<br><br>8,516,993 DKK | Total realised monetary Value |
| Effectiveness Benefits - Quantifiable but Non-Financial | Total forecast score / 100<br><br>None identified | Total realised score /100 |
| Business Performance Benefits - Non-Quantifiable and Non-Financial | ▪ Improved company image B<br>▪ Improved ability to win new projects B<br>▪ Reduction of failed paradigms search B<br>▪ Reduced time spent on version control (using Mark-up facility) B<br>▪ The virtual working place A<br>▪ Reduced time spent on not found drawings D<br>▪ Reduction of number of times working with wrong drawing(s) B<br>▪ Improved drawing quality using best practices A | |

The cost saving from DWS is calculated as 8,516,993 DKK over a period of 5 years, but the output is limited because the costs are not included in these figures. The output means that Cowi can save approximately 8.5 million DKK during the five year lifetime of the IT investment compared to not implementing DWS.

None of the identified benefits could be categorised as effectiveness benefits as shown in the second row of *Table 14*. A few benefits were initially categorised as effectiveness benefits but were later, in the IT evaluation process, changed to performance benefits because it was too difficult to estimate the necessary attributes. An example of this is the benefit "Reduced time spent on not found drawings" which, in the first attempt, was categorised as an effectiveness benefit because of its apparent measurability.

The third row in *Table 14* shows the identified performance benefits and their ratings. 8 performance benefits were identified. Two of the performance benefits were judged as being very significant (rated as A), five of them were rated as being significant (B), and one was rated as being low (D).

Overall it can be concluded that Cowi can save a significant amount of money by using DWS. The non-measurable benefits are generally judged as significant except the benefit "Reduced time spent on not found drawings". The output of the method show a positive and significant effect on the company and would therefore be likely to be approved.

### 6.3.4 Information Economics

The output sheet from IE for the evaluation of DWS is seen in *Figure 28*. The spreadsheet containing the more detailed data used in this method, can be found in Appendix C10.

| | ROI | SM | CA | MI | CR | OR | SA | DU | TU | IR |
|---|---|---|---|---|---|---|---|---|---|---|
| factor | + | + | + | + | + | - | + | - | - | - |
| **Business Domain** | 1 | 4,5 | 4,5 | 4,5 | 4 | 0,5 | | | | |
| **Technology Domain** | | | | | | | 5 | 0,5 | 1 | 0,5 |
| Weight distribution | 4,5 | 5,0 | 5,0 | 4,5 | 4,0 | 4,5 | 4,5 | 4,0 | 4,0 | 4,5 |
| Sum | 4,5 | 22,5 | 22,5 | 20,25 | 16 | 2,25 | 22,5 | 2 | 4 | 2,25 |
| **Total Value** | **108,25** | out of | max. | 150 | and | min. | 0 | | | |
| **Total Risk** | **10,5** | out of | max. | 100 | and | min. | 0 | | | |

*Figure 28. Output sheet from IE*

One value factor, *Strategic IS architecture* (SA), achieved the highest mark because the IT investment is considered as a part of the blueprint and is a prerequisite to other IT systems in the company. Three other value factors achieved the mark 4.5 because they nearly reached the scale's highest mark.

The ROI factor has, because of a relatively low cash flow, resulted in a ROI score of 4.6 % (20 % means break-even). The low ROI results in a low mark of 1 primarily because the costs are higher than the benefits achieved throughout the IT investment lifetime.

Analysing the risk factors, none achieved the best mark (which for risk factors is 0). The risk factors given 0.5 are: *Project and organisational risk* (OR), *Definitional uncertainty* (DU) and *IS infrastructure risk* (IR). The marks were generally achieved because the IT investment implies a minimal risk for the company since the company has well defined plans for how to implement DWS and, in using DWS, almost no upfront costs are anticipated. The worst mark given for the risk factors is 1 (given to the factor *Technical uncertainty* (TU)). Overall this results in a relatively low total risk.

Two factors have been assigned a weight of 5 and these are the factors *Strategic match* (SM) and *Competitive advantage* (CA). These two factors are viewed by the company as the most important ones. The economic domain of the IT investments is regarded as an important factor (weighted 4.5). None of the factors have been given a weight of 0. This means that all 10 factors can have an impact on the final score.

In this case the total value for implementing DWS is calculated as 108.25. Taking into consideration that the two extremes are 0 and 150, it is placed in the upper third part of the scale. This is considered as very good, but the total value is not very informative, whereas useful information about the IT investment has been revealed through using the method and three significant areas have been highlighted using IE.

First, the method has identified and estimated that the IT investment is not profitable in terms of reaching break-even.

Second, three factors in the IT evaluation have a significant impact on the total value by contributing with a value on 22.5 each.

- Strategic match
- Competitive advantage

- Strategic IS architecture

Third, the method has identified that the technology factors do not have a large impact on the total risk (the total risk is estimated as 10.5). This means that the IT investment is considered as a technological benefit and that the technological risk and uncertainties from the IT investment are low.

Overall it can be concluded that the IT investment has a significant positive impact on the company. It can therefore be concluded that using this method would approve the IT investment.

### 6.3.5 Critical Success Factors

The five interviewed stakeholders identified several different critical success factors (the complete list of critical success factors can be seen in Appendix C11 p. 71). They are derived from a series of short interviews with different stakeholders (see the following Appendices C2 and C11).

The identified critical success factors are listed in random order:

- The end-users should be motivated to use DWS by achieving some benefits, but it should also benefit the company (4)
- The end users' understanding of DWS's usefulness and the functionalities provided have to be good
- DWS has to provide the promised functionalities
- The introduction of DWS to the end-users has to be good
- DWS has to support the need in Cowi's different departments and in large and small projects.
- The top management has to approve and support the usage of DWS (3)
- The person responsible for DWS daily operations has to be involved in the development and implementation process
- The responsibilities have to be defined and placed on specific employees
- Some introduction to DWS is necessary but in general it has to be self explanatory
- During the decision and implementation process it is necessary that the end users are involved
- DWS has to be integrated with the other IT applications used to create the CAD drawings.
- It is important to be patient with the development (by not quitting at the first barrier) because the changes are implemented very slowly
- DWS has to be accepted as the way documents are created and managed by the end users
- The end users have to have an easy access to DWS
- The technology has to be configured optimally and provide functionalities beneficial for the end users (2)
- The project leaders have to accept and support the new working procedures by using DWS
- DWS has to support all types of document (not just CAD drawings) (2)
- The testing of DWS has to be done properly so that it works without major problems
- The support and development of DWS have to be continuous
- The end users have to be allowed some flexibility in the way they work

Whenever a similar critical success factor is identified by several of the stakeholders the multiplicity is written in brackets.

The three most important factors for ensuring success with DWS were identified as the following:

- The end users should be motivated to use DWS by achieving some benefits but it should also benefit the company
- The top management has to accept and support the usage of DWS
- The testing of DWS has to be done properly so that it works without major problems

The most important critical success factor was identified as the end users' motivation and benefits achieved from using DWS. This factor was identified by 3 of the stakeholders as the most important.

A wide range of critical success factors has been identified from the end users' satisfaction to strategic level approval of the IT investment, to testing the DWS before it is released. None of them is specifically referring to the economic impact of the IT investment.

On the basis of the identified critical success factors it is difficult to conclude whether the implementation of DWS should be approved or not. All five stakeholders considered the implementation of DWS as a beneficial IT investment. The implementation process has been found by all the stakeholders to be problematical.

### 6.3.6 Comments on the methods' output

The most negative output was produced by NPV and the conclusion, on the basis of the financial value, would have to be a rejection of the IT investment because all IT investments with a negative net present value are not considered as beneficial to the company.

IE has produced two output that signify a relatively large total value and also a small risk. Depending on how the company analyses the output of the method, they can be used as an argument for either approving or rejecting the IT investment. It is however believed that this IT investment will probably be approved if this method is used in the IT evaluation.

The third method, MBITI, produces more multi-dimensional output. The conclusions, which can be drawn from the output, are generally positive and the IT investment would, on the basis of these output, therefore probably be approved. However this depends on the company's approval criteria.

In total 20 different critical success factors were identified by the five stakeholders interviewed. The most important factor was the motivation of the end users to use DWS and the perceived benefits achieved. The output of this method is not good for making conclusions if the purpose is to evaluate the impact on the company by using DWS. It cannot therefore be concluded whether the IT investment should be approved or not using this method.

## *6.4 NIRAS*

The third case study, with NIRAS, evaluates the company's future projectweb strategy. The output from four methods are presented and the conclusions that can be derived from this are commented on.

### 6.4.1 Assumptions and limitations

The first assumption made is about the uncertainty in end-users' requirements for a projectweb. In this very early stage of the IT investment the end-users' requirements have not been identified, which makes the choice for a projectweb strategy very difficult to complete. It is therefore assumed that the requirements are limited to the most basic functionalities provided by a projectweb.

If this assumption is not true then it might imply that the end users will be very disappointed in the functionalities provided in the projectweb. This can have a severe influence on the end users' motivation. Another extreme is choosing not to use a projectweb in which some of the same reactions from the potential end users can be expected.

Another related assumption is that the benefits from using an in-house developed projectweb inheriting some functions, compared to an externally developed projectweb, are not clear. It is therefore assumed that the cost of developing such a projectweb in-house is larger than the benefits achievable. This assumption implies that the alternative of developing an advanced projectweb is not taken into consideration.

It is difficult to predict the consequences of this assumption if it is not valid. One thing that can be argued is that the consequences of this assumption are less critical than if the opposite assumption is taken.

No major limitations were identified in this IT evaluation.

### 6.4.2 The financial and quantitative oriented methods

The three financially oriented methods were not completed in this case study because it was judged, by the case study company, that too many resources were needed to complete the identification and estimation of the costs and benefits compared to the achievable results and their preciseness.

Since it was not possible to identify and estimate the costs and benefits for the alternative projectweb strategies (described in chapter 5) the financially oriented methods could not be completed.

### 6.4.3 Critical Success Factors

Two stakeholders in the usage of projectwebs have been interviewed (a summary of these interviews can be found in the following Appendices D3 and D5).

The following critical success factors were identified.

- The justified demands for the projectweb have to be fulfilled
- The projectweb has to be stable
- The end users have to identify the potential benefits of using the projectweb and thereby be motivated (2)
- The cost of the projectweb has to be appropriate compared to the facilities provided
- The projectweb has to provide benefits and/or functionalities that are desirable for the end users
- The procedures for how to use the projectweb have to be agreed beforehand. It is also necessary to ensure that the procedures are felt to be less bureaucratic than using the traditional means.
- It is important not to make the procedures so complicated and advanced that they are considered as a constraint or barrier.
- The project members have to change their behaviour and be more active in ensuring that they have the latest updated version of the electronic documents.
- The attitude to using the projectweb has to be changed by some of the project members.
- It is important to agree which CAD version is used in order to enable all the project members to read the electronic documents

The two most important factors for ensuring success with a projectweb were identified to be the following:

- The justified demands for such an IT system have to be fulfilled
- The project members have to be convinced that the projectweb is a beneficial system and not consider it as a constraint.

The most important critical success factor was identified to be the end users motivation and benefits achieved from using a projectweb.

Some different critical success factors have been identified ranging from the end-users' motivation, to changes in working procedures, to the stability of the projectweb. One of them is specifically referring to the economic impact of the IT investment.

Identifying the critical success factors has given the company a better understanding of the end – users' requirements and the method has, in that perspective, provided some valuable information. The method, CSF, is therefore considered as useful in this context.

### 6.4.4 Comments on the methods' output

Only the output provided by CSF is commented on because the other methods were not completed.

10 different critical success factors were identified. This method is considered as useful, not because it was the only method completed, but because it provided the company with a better understanding of the requirements to be fulfilled by the IT investment. An example is that most of the identified critical success factors are not about the technology but are mostly focused on the usage of the projectweb.

## 6.5 Højgaard & Schultz

The fourth case study described is with H&S. The output from four methods are presented on the basis of the evaluation of two different projectwebs, IHD and ProjectNet.

### 6.5.1 Assumptions and limitations

The lifetime for the two projectwebs is estimated as two years because it was judged likely that the nature of projectwebs would change radically in that time. It would then be necessary to evaluate the availability of projectwebs once again.

The development of projectwebs is fast and new ones are becoming available regularly. This rapid development implies that the IT evaluation champion did not believe that he was able to estimate the benefits' value precisely, without limiting some of the uncertainties related to the projectwebs. The IT evaluation champion therefore felt that describing a vision for how the projectweb was used in a two-year timescale, could improve the precision of the estimated benefits, as it could be used to identify the level of projectweb usage.

One major limitation made in this IT evaluation is briefly described in the following.

In order to evaluate the two projectwebs it has been necessary to limit the scope of the IT investment. It was decided that the two projectwebs should be evaluated on the basis of one, two-

year long building project. The decision was taken because it was considered difficult to evaluate the usage of a projectweb in the whole company.

This limitation is very significant because the projectwebs are very different in terms of functionalities provided. This means that ProjectNet might be suitable for only large building projects, whereas IHD is suitable for smaller projects. The consequence of the decision is that the conclusions derived on the basis of the IT evaluation can only be used for comparing the projectwebs on a single building project that is relatively large. It cannot be used for comparing the usage of projectwebs for all of H&S's building projects

This section focuses on presenting the output from the four IT evaluation methods used on the case study with Højgaard & Schultz.

### 6.5.2 Net Present Value

The discounted cash flow for IHD can be seen in *Figure 29*. The first year results in a worsening of the return but is improved slightly by a positive cash flow in year two. Calculating the net present value of IHD reveals a negative return of **–404,940 DKK** (for further information see Appendix E7 p. 111).

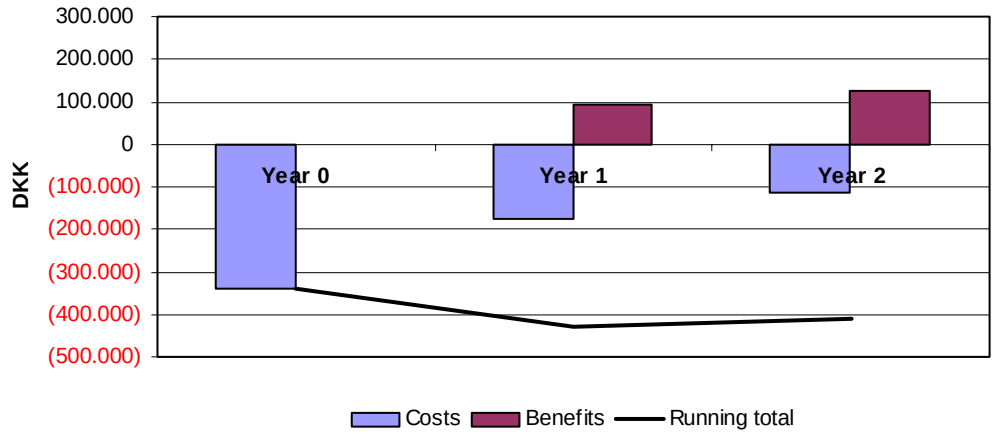



*Figure 29. Discounted cash flow of IHD*

Almost the same pattern can be identified for ProjectNet as seen in *Figure 30* but, in this case, the yearly cost is the most influential whereas the investment cost is relatively low. The net present value for ProjectNet is also negative and has been calculated as **–177,637 DKK** (see Appendix E7 p.113).

The costs and benefits for the two projectwebs can be found in the respective Appendices E5 p. 101 and 103 and E6 p. 105 and 108.

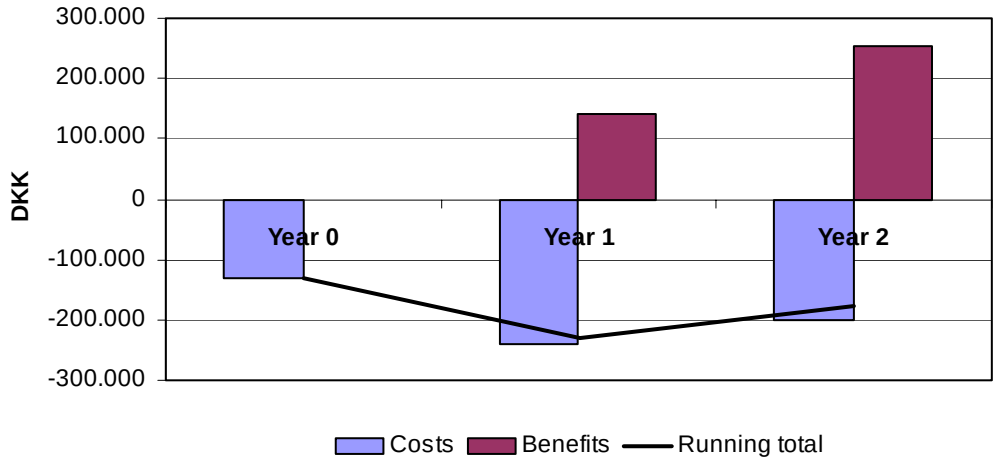



*Figure 30. Discounted cash flow of ProjectNet*

From the discounted yearly cash flow in *Figure 29* and *Figure 30* it can be seen that both projectwebs result in a negative return. Although the yearly cost for ProjectNet is higher than for IHD it generates a better financial return. The primary reason why the net present value is negative for both projectwebs is the start-up costs but, by analysing the yearly cash flow, it reveals that this is also negative in year 1.

Based on the output from NPV it can be concluded that neither projectwebs result in a positive financial value and this means that neither of them should be approved on the basis of the output from NPV.

### 6.5.3 Measuring the Benefits of IT Innovation

The following table shows the summarised output from using MBITI for IHD and ProjectNet. The more detailed completion of MBITI can, for IHD and ProjectNet, be seen in Appendix E8 p. 115, 120 and 123.

*Table 15. Output sheet from MBITI for IHD*

| Type of Benefits | Expected Benefits<br>In-house developed projectweb | Measured Benefits |
|---|---|---|
| Efficiency Benefits -<br>Quantifiable and Financial | Total forecast monetary value<br>239,830 DKK | Total realised monetary Value |
| Effectiveness Benefits -<br>Quantifiable but Non-Financial | Total forecast score / 100<br>None identified | Total realised score /100 |
| Business Performance<br>Benefits - Non-Quantifiable and Non-Financial | **Business planning**<br>Improve and sustain company image A<br>Sustain competitive position C<br>**Information Management**<br>Improve efficiency of distributing electronic documents B<br>Improved information exchange with architect A<br>Reduced costs of archiving C<br>Improved information of time schedule D<br>Improved progress and clarification questions D<br>Improved documentation of the building process B<br>**Client Management**<br>Improved information exchange with client C<br>**Design**<br>Improve efficiency of distributing electronic documents B<br>Improved information exchange with architect A<br>Reduced rework because of wrong drawings A<br>Improved information of time schedule D<br>Improved progress and clarification questions D<br>**Construction**<br>Improve efficiency of distributing electronic documents C<br>Improved information exchange with architect C<br>Reduced rework because of wrong drawings A<br>Improved information of time schedule D<br>Improved progress and clarification questions D<br>**Operation and Maintenance**<br>Production of O&M manual A | |

*Table 16. Output sheet from MBITI for ProjectNet*

| Type of Benefits | Expected Benefits ProjectNet | Measured Benefits |
|---|---|---|
| Efficiency Benefits - Quantifiable and Financial | Total forecast monetary value<br>305,000 DKK | Total realised monetary Value |
| Effectiveness Benefits - Quantifiable but Non-Financial | Total forecast score / 100<br>None identified | Total realised score /100 |
| Business Performance Benefits - Non-Quantifiable and Non-Financial | **Business planning**<br>Improve and sustain company image A<br>Sustain competitive position C<br>**Information Management**<br>Improve efficiency of distributing electronic documents A<br>Improved information exchange with architect A<br>Reduced costs of archiving C<br>Improved information of time schedule B<br>Improved progress and clarification questions B<br>Improved documentation of the building process A<br>**Client Management**<br>Improved information exchange with client C<br>**Design**<br>Improve efficiency of distributing electronic documents A<br>Improved information exchange with architect A<br>Reduced rework because of wrong drawings A<br>Improved information of time schedule C<br>Improved progress and clarification questions B<br>**Construction**<br>Improve efficiency of distributing electronic documents C<br>Improved information exchange with architect C<br>Reduced rework because of wrong drawings A<br>Improved information of time schedule B<br>Improved progress and clarification questions B<br>**Operation and Maintenance**<br>Production of O&M manual A | |

*Table 15* and *Table 16* shows for IHD and ProjectNet, financially measurable benefits of, respectively, 239,830 DKK and 305,000 DKK if they were implemented. The output are calculated

on the basis of an IT investment's lifetime of two years, compared with not implementing the projectweb.

None of the identified benefits could be categorised as effectiveness benefits so therefore this result is not applicable either for IHD or ProjectNet.

20 performance benefits were identified as valid in both projectwebs, however, many of them are not estimated as equally important. For IHD six of the performance benefits were judged as being very significant (rated as A), three of them were rated as being significant (B), five were rated as being moderate (C) and six were rated as being low (D). Many of the non-measurable benefits are therefore do not have a great influence on the overall result. For ProjectNet nine of the non-measurable benefits are rated as very significant (rated as A), five of them were rated as being significant (B), six were rated as being moderate (C) and none were rated as being low (D). In general the non-measurable benefit for ProjectNet is rated higher than for IHD and therefore has significantly better output.

From *Table 15* and *Table 16* it can be concluded that using either IHD or ProjectNet can save a relatively small amount of money (when no data on the cost is included). A large proportion of the identified benefits was categorised as non-measurable for both projectweb alternatives, however, IHD's non-measurable benefits were rated significantly lower. The output from MBITI for both projectwebs show a positive, but low, effect on the company and should therefore be a topic of discussion at the strategic level of the company.

### 6.5.4 Information Economics

*Figure 31* and *Figure 32* display the mark given for each of the 10 factors, the estimate of the company weightings, and the final scores for IHD (see Appendix E9 p. 126) and ProjectNet (see Appendix E9 p. 130).

| | ROI | SM | CA | MI | CR | OR | SA | DU | TU | IR |
|---|---|---|---|---|---|---|---|---|---|---|
| factor | + | + | + | + | + | - | + | - | - | - |
| **Business Domain** | 1 | 4 | 4 | 2 | 2 | 2 | | | | |
| **Technology Domain** | | | | | | | 1 | 2 | 2 | 1 |
| Weight distribution | 4 | 5 | 5 | 4 | 5 | 4 | 5 | 3 | 4 | 4 |
| Sum | 4 | 20 | 20 | 8 | 10 | 8 | 5 | 6 | 8 | 4 |
| **Total Value** | **67** | out of | max. | 150 | and | min. | 0 | | | |
| **Total Risk** | **26** | out of | max. | 100 | and | min. | 0 | | | |

*Figure 31. summary sheet from IE for IHD*

| | ROI | SM | CA | MI | CR | OR | SA | DU | TU | IR |
|---|---|---|---|---|---|---|---|---|---|---|
| factor | + | + | + | + | + | - | + | - | - | - |
| **Business Domain** | 1 | 4 | 4 | 2 | 2 | 2 | | | | |
| **Technology Domain** | | | | | | | 1 | 4 | 1 | 0 |
| Weight distribution | 4 | 5 | 5 | 4 | 5 | 4 | 5 | 3 | 4 | 4 |
| Sum | 4 | 20 | 20 | 8 | 10 | 8 | 5 | 12 | 4 | 0 |
| **Total Value** | **67** | out of | max. | 150 | and | min. | 0 | | | |
| **Total Risk** | **24** | out of | max. | 100 | and | min. | 0 | | | |

*Figure 32. Summary sheet from IE for ProjectNet*

None of the six value factors were given the highest mark for either of the two projectwebs.

The ROI factor has, because of a relatively low cash flow in both projectwebs, resulted in a ROI score of, respectively, 21.2% and 64.8 % (50 % would mean break-even for both projectwebs). The low ROI results in a low mark of 1 for both projectwebs. The ROI for IHD implies that the IT investment costs are higher than the benefits achieved through the IT investment lifetime, whereas ProjectNet's ROI is above break even. Even though there is a significant difference in the profitability of the two projectwebs, they are still given the same mark.

The risk factor called *IS infrastructure risk* was, for ProjectNet, given the best mark (which is 0). It was judged that the IS infrastructure of ProjectNet was already in place and would therefore not be the source of additional costs. Analysing IHD with respect to this risk factor revealed that some minor changes in the IS infrastructure were needed and therefore it was given the mark 1. The worst mark given to any of the risk factors is 2. In general it can be concluded that the risk factors are higher for IHD than ProjectNet. Nevertheless the risk factors result in a relatively low total risk for both projectwebs.

Four factors have been assigned a weight of 5 and these are: *Strategic match* (SM), *Competitive advantage* (CA), *Competitive response* (CR) and *Strategic IS architecture* (SA). These four factors are regarded as the most important ones. None of the factors have being given a weight of 0. This means that all 10 factors can have an impact on the final score.

The total value for IHD is calculated as 67. Taking into consideration that the two extremes are 0 and 150, the final score is in the middle of the scale. This is considered as relatively good. The total value for ProjectNet is calculated as 67 which, surprisingly, is the same as for IHD. This means theoretically that the two projectwebs are equally desirable.

The total risk is, for IHD and ProjectNet, calculated to be respectively, 26 and 24. This indicates that the risk is considered higher if the projectweb is developed in-house than if it is ProjectNet. The difference in total risk is however small and the conclusions derived on the basis of this should be made with some caution.

Using IE has identified and estimated that ProjectNet is reasonably profitable in terms of reaching break-even, whereas IHD has a lower ROI. This might however be strongly influenced by the short lifetime of the IT investment. Two factors in the IT evaluation have a significant impact on the total value by each contributing a value of 20. This is valid for both projectwebs: *Strategic match* and *Competitive advantage.* IE has furthermore identified that the risk factors are considered as moderate (the total risk is, for IHD and ProjectNet, estimated as, respectively, 26 and 24). This means that the projectwebs are largely considered as IT investments with a relatively low risk.

Overall it can be concluded that the projectwebs have a moderately positive impact on the company and that total risk is relatively small. Using IE would probably result in approval of both of the projectwebs. Comparing the projectwebs using this method would mean that ProjectNet is the best projectweb, but some caution has to be taken when conclusions are derived on the basis of such a small difference between the output from IE.

### 6.5.5 Critical Success Factors

The four interviewed stakeholders identified several different critical success factors. One of the stakeholders focused on the critical success factors of IHD and another on ProjectNet. Summaries of the stakeholder interviews upon which the critical success factors have been derived can be seen in Appendix E10. A combined list of the critical success factors is found in Appendix E10 p. 138.

The critical success factors are, in the following, listed in random order, but grouped according to the evaluated IT investment:

**General critical success factors**

- The project leaders have to trust and believe in the projectweb as an important tool (2)
- The project leaders have to make sure that the projectweb is implemented and used properly in all of the project's collaborating companies
- The project leaders have to act as role models by using the projectweb themselves instead of sending paper copies
- The end users' IT capabilities should be upgraded through education or courses
- The ability to differentiate between the electronic documents' importance for one's own job should be emphasised (2)
- The projectweb should have an improved functionality focusing on sorting the relevant information stored on the server
- More responsibility and resources (earmarked for the projectweb) need to be given to the project leader
- The projectweb should reduce the cost of building projects
- The administration of user rights has to be organised and some possibility for sorting the documents has to be enabled
- The possibility of registering the usage of the projectweb (logging-on) has to be in place
- The interfaces (browsers) that enable the end-user to see the documents are important for a projectweb (if not the end-user will have to install the full versions of the IT applications used to generate the documents)
- The communication lines to the building sites have to capable of running the projectweb
- The communication lines (their bandwidth) have to be big enough to meet the data transfer needs
- The top management support for using the projectweb has to be in place (3)
- The end users have to experience the projectweb as beneficial to their working procedures and not as an administrative procedure

**IHD**

- The end users have to accept the new IT technology especially the project leaders
- Better facilities for assigning new project members that can be given certain rights in the projectweb
- The usability of the in-house developed projectweb has to be high or else the project members will reject the IT system because it will be a constraint on their working activities.
- The type of projectwebs used have to be adjusted to the actual need or, either the costs will be too high, or the need for functionality will not be fulfilled.

**ProjectNet**

- The project members and partner are motivated and involved in using the ProjectNet.
- The computer (hardware and software) should be fast enough.
- The subcontractors should have the necessary IT maturity and capacity for using the ProjectNet.
- A good introduction to the ProjectNet
- The working procedures have to be adjusted to the use of ProjectNet.
- The structure of directories and documents on the projectweb has to be standardised.

Whenever a similar critical success factor is identified by several of the stakeholders the multiple number is written in brackets.

The three most important factors for ensuring success with a projectweb were identified to be the following:

- The top management support for using the projectweb has to be in place. (3)
- The project members and partners are motivated and involved in using the projectweb.
- The usability of the projectweb has to be high or else the project members will reject using the IT system because the system will be seen as a constraint on their working activities.

A wide range of critical success factors has been identified from the education of end-users, to strategic level approval, to technical requirements. One of them is specifically referring to the economic impact of the IT investment.

On the basis of the identified critical success factors it is again difficult to conclude whether the choice of projectweb should be IHD or ProjectNet. It should be acknowledged that the identified critical success factors might provide valuable inputs to the identification of requirements for the chosen projectweb. In this perspective the method provides useful output.

All four stakeholders considered the usage of a projectweb as a beneficial IT investment.

### 6.5.6 Comments on the methods' output

Again the most negative output is produced by NPV and the conclusion would, on the basis of the output, have to be a rejection of both projectwebs. ProjectNet is the projectweb that has the lowest negative net present value and therefore should be regarded as the best IT investment.

IE has produced two output that imply a moderate total value (67) for both projectwebs and a low risk (26 (IHD) and 24 (ProjectNet)). Depending on how the company analyses the output of the method, the output can be used as an argument for either approving or rejecting the IT investment. With regard to choosing between the projectwebs it would, on the basis of IE's output, be ProjectNet. However, choosing ProjectNet because of a difference of two points in the total risk is problematic because of the uncertainties in the data used to derive the output.

The third method, MBITI, produces more multi-dimensional output. The conclusions, which can be drawn from the output, are generally positive and both projectwebs would, on the basis of this output, therefore most likely be approved. This is, however, depending on the company's approval criteria. Using this method it can be concluded that ProjectNet has the best output. The difference in the efficiency output is small between the projectwebs but, comparing the performance benefits, it can be seen that ProjectNet has significantly better output than IHD.

The last method, CSF, has identified many critical success factors which are useful for identifying the company's requirements for the choice of projectweb. Using the method's output to derive a conclusion on which projectweb they should choose is difficult because of the format of the output. It cannot therefore be concluded which of the projectwebs is the best for H&S on the basis of the output from this method.

## 6.6 Troels Jørgensen A/S

The fifth and last case study described is evaluating the implementation of a CITRIX application (see chapter 5 for a more detailed description of the IT investment) in Troels Jørgensen A/S. The output from four methods, and a few general comments on the output from the methods, are presented.

### 6.6.1 Assumptions and limitations

The first assumption has a significant impact on the output of the methods. The lifetime for the CITRIX application is estimated as three years because that is the typical time horizon the company uses in their planning.

A part of the current effectiveness of TJAS's production of the company's accounts is based on the existing working procedures used. These will, with the functionalities offered by CITRIX, not be appropriate any more. It is therefore assumed that the working procedures will be amended so that they take advantage of the CITRIX application instead of constraining the administrative staff.

Not amending the working procedures could result in an inefficient production of company accounts and may therefore limit the benefits achieved. It may furthermore be found to be a hindrance to the end users if the administrative staff execute working procedures not supported by the functionalities offered by CITRIX.
CITRIX is by nature an IT application that enhances the IT infrastructure of the company. It will therefore not, in itself, provide benefits. These are usually achieved by implementing other IT applications that can exploit the advantage of the functionalities offered by CITRIX. In this IT evaluation the primary objective of the IT investment was to centralise the production of company accounts, which is achieved through the company's economic system, and will therefore be considered as a part of the IT evaluation.

One major limitation made in this IT evaluation is identified as follows.

Only end user benefits achieved by the administrative staff and the clerks of works will be included in the IT evaluation. The company would probably achieve other end user benefits too, but these were judged as too difficult to identify and estimate and are therefore not included.

This section focuses on presenting the output from the four IT evaluation methods used on the case study with Troels Jørgensen A/S.

### 6.6.2 Net Present Value

From the estimated cash flow for the IT investment during a three year period, a chart can be drawn as shown in *Figure 33*. A detailed calculation of the net present value can be seen in the Appendices F5, F6 and F7.

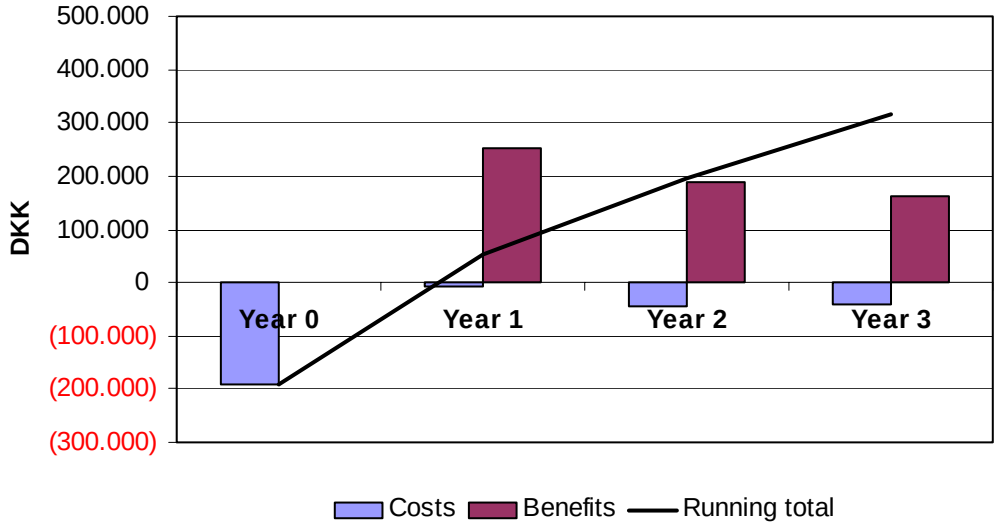



*Figure 33. The IT investment's cash flow*

The net present value of the IT investment was calculated as **316,963 DKK**. The net present value is larger than 0 and therefore means that the IT investment results in a financial benefit.

In *Figure 33* it can be seen that the yearly benefits are slowly decreasing and the same tendency is valid for the running costs. It can also be seen that the cash flow is positive thorough all three years. The running costs estimated for the first year are minor whereas the benefits are significantly higher resulting in a positive return, even if the initial investment is included.

Based on the output from NPV it can be concluded that the CITRIX application results in a positive financial return. This means, in other words, that the IT investment should be approved on the basis of NPV.

### 6.6.3 Measuring the Benefits of IT Innovation

The following table shows the summarised output from MBITI whereas the more detailed completion of MBITI can be found in Appendix F8.

*Table 17. "Presentation" sheet from MBITI*

| Type of Benefits | Expected Benefits | Measured Benefits |
|---|---|---|
| Efficiency Benefits - Quantifiable and Financial | Total forecast monetary value<br>657,000 DKK | Total realised monetary Value |
| Effectiveness Benefits - Quantifiable but Non-Financial | Total forecast score / 100<br>None identified | Total realised score /100 |
| Business Performance Benefits - Non-Quantifiable and Non-Financial | ▪ Increased security of economy data A<br>▪ Ability to use the company's IT applications whenever and wherever A<br>▪ Increased usage of IT applications like MS Project C<br>▪ Improved access to electronic data D<br>▪ Reduced costs of back-up procedures (local data) A<br>▪ Increased capacity of administrative staff A<br>▪ Reduced costs of accountants fee C<br>▪ Increased quality of company's accounts D<br>▪ Improved satisfaction of administrative staff B | |

The cost saving from using CITRIX is calculated to be 657,000 DKK over a period of 3 years (the cost is not included in this calculation). The output is estimated on the basis of a comparison with deciding not to implement the CITRIX application.

Through an analysis of the identified benefits, where they were categorised according to their measurability, none of them was found to belong to the *Effectiveness table* as indicated in the table.

The last row in *Table 17* shows the identified performance benefits and their estimated ratings. 9 performance benefits were identified. Four of the performance benefits were judged as being very significant (rated as A), one of them was rated as being significant (B), two were rated as being moderate (C) and two judged as low (D). Several high-rated, non-measurable benefits were identified and this has an influence on the overall result of the IT investment.

The conclusion that can be drawn from *Table 17* is that a significant amount of money can be saved by implementing CITRIX. The non-measurable benefits are generally judged as significant except for the benefits “Improved access to electronic data” and “Increased quality of company's accounts”. The output of NPV shows a positive and significant effect on the company and would therefore be approved if this method were used.

### 6.6.4 Information Economics

*Figure 34* shows the output sheet from IE (the whole completion of IE can be found in Appendix F9).

| | ROI | SM | CA | MI | CR | OR | SA | DU | TU | IR |
|---|---|---|---|---|---|---|---|---|---|---|
| factor | + | + | + | + | + | - | + | - | - | - |
| **Business Domain** | 1 | 4 | 3 | 3 | 2 | 0 | | | | |
| **Technology Domain** | | | | | | | 3 | 2 | 3 | 3 |
| Weight distribution | 5 | 5 | 4 | 5 | 4 | 4 | 4 | 1 | 4 | 4 |
| Sum | 5 | 20 | 12 | 15 | 8 | 0 | 12 | 2 | 12 | 12 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Total Value** | **72** | out of | max. | 150 | and | min. | 0 |
| **Total Risk** | **26** | out of | max. | 100 | and | min. | 0 |

*Figure 34. Final output from IE*

None of the value factors were given the highest mark (5) or the lowest mark (0). The reasons for this are many but, in general, it was judged that the IT investment did not fulfil the requirements defined in the scales used to mark the factors.

The ROI factor has, because of a positive cash flow, resulted in a ROI score of 166.1% (33 % means break-even). The ROI ratio implies that the IT investment's financial value is higher than the costs through the IT investment lifetime. Even though the IT investment has a good ROI which results in a mark of 1.

The risk factor, *Project and organisational risk*, was given the best mark (which is 0). The other risk factors were given a mark of either 2 or 3 which means that there are some risks associated with the IT investment.

Three factors out of 10 have been assigned a weight of 5 and these are the factors *Return on Investment* (ROI), *Strategic match* (SM) and *Management Information* (MI). They are viewed by the company as the most important ones. None of the factors have been given a weight of 0 and this implies that all 10 factors can potentially have an impact on the final score.

The total value for implementing CITRIX is calculated as 72. Taking into consideration that the two extremes are 0 and 150, it is placed in the middle of the scale and this can be considered as good. In itself the total value is not very informative but some information about the IT investment can be used to get a more detailed picture of the IT investment.

Using IE has identified and estimated that the IT investment is reasonably profitable in terms of reaching break-even. Two factors in the IT evaluation are having a significant impact on the total value by contributing with values of: *Strategic match* (20) and *Management Information* (15). IE has identified risks associated with the IT investment are moderate. Two risk factors mainly result in the moderate risk level. These are *Technical uncertainty* and *IS infrastructure risk* and each contributes with 12 out of a total risk of 26.

Overall it can be concluded that the IT investment has a significantly positive impact on the company. It can therefore be concluded that using IE would probably mean an approval of the CITRIX application.

### 6.6.5 Critical Success Factors

Three interviewed stakeholders identified, through a series of short interviews, several different critical success factors. The summaries can be found in the following Appendix F3 and F10. A combined list is also found in Appendix F10 p. 168.

The critical success factors are listed in random order:

- The network and the telephone lines have to be stable (2)
- The company should recognise the importance of using the CITRIX application
- The company should be patient and make sure that the IT investment is consolidated in the company
- It is important that the server is upgraded frequently so it is capable of supporting the end users
- It has to be stable and the configuration has to be 100% optimised (2)
- The end users have to be educated in using the new way of accessing Concorde XAL using CITRIX (2)
- The economic data has to be protected so that no one can gain access.

Whenever a critical success factor is identified by several of the stakeholders the multiple number is written in parenthesis.

The two most important factors for ensuring success with CITRIX were identified to be the following:

- The company should recognise the importance of using the CITRIX application
- It has to be stable and the configuration has to be 100% optimised (2)

The most important critical success factor was identified to be the IT system's stability and configuration. This factor was identified by 2 of the stakeholders as the most important.

A wide range of critical success factors has been identified, from the end –users' education, to company approval of the IT investment, to testing of CITRIX before it is released. None of them is specifically referring to the economic impact of the IT investment.

On the basis of the identified critical success factors, it is difficult to conclude whether the implementation of CITRIX should be approved or not because the factors are not describing the actual IT investment's cause-effect relationship but rather the requirements that have to be fulfilled. All three stakeholders considered the implementation of CITRIX as a beneficial IT investment, but that the implementation of CITRIX should have been done better.

### 6.6.6 Comments on the methods' output

NPV is, in this case, producing a positive net present value that is only the case in one of four case studies. The IT investment would therefore result in a positive financial impact on the company and would be approved as promising.

IE confirms this conclusion by providing output that imply a high total value and a moderate risk. The conclusion about whether it should be approved is, however, dependent on the company approval criteria.

The third method, MBITI, provides more detailed output, which are useful when wanting to have an overview of the consequences of the IT investment. In general both the economically measurable and non-measurable benefits show that the CITRIX application is a good IT investment that would probably be approved.

The last method, CSF, identifies 7 critical success factors ranging from education of end users to the stability of networks and telephone lines. Also, in this case study, the method's output cannot be used to determine the IT investment's impact on the company.

## 6.7 Comparative comments on the output from the case studies

The last section in this chapter compares the output from the methods. The comparison is based on the experience gained by completing the four methods in the case studies.

NPV provides a negative output in three out of four case studies indicating that the case studies' IT investments, when using a financial criterion, in most cases would be rejected. When comparing NPV's output with both MBITI's and IE's, it is shown that the two later methods provide more positive output which would not necessarily result in a rejection of the IT investments. This indicates that NPV only should be used in evaluating IT investments in which the primary impact is financially measurable.

Both MBITI and IE produce output that include several IT evaluation criteria and are therefore more complex than NPV. A few differences in the output from MBITI and IE have been revealed. The most notable difference is that IE combines the estimates of the different IT evaluation criteria into a few output, whereas MBITI presents them separately. This had an influence on how the output were viewed in the case studies depending on the IT evaluation champions. The second notable difference is that IE is providing output that are easier to use for decision making whereas MBITI's output need to be analysed in order to derive a decision.

So far CSF has not been mentioned, which is primarily because the method is radically different than the three other methods. The primary difference is that the first three methods are useful in evaluating the impact of the IT investment, whereas CSF is useful when evaluating which requirements are needed when choosing between the IT investments. Because of this CSF has been of limited use in the case studies as four out of five case studies are focused on evaluating the impact from the IT investment.

## 6.8 Summary

In this chapter the output from the four IT evaluation methods in each case study have been presented and commented on.

Briefly it is shown that NPV is only useful in evaluating IT investments in which the primary impact is financially measurable, whereas both MBITI and IE are considered useful in IT evaluations where the impact from the IT investment is both quantitative and qualitative. Lastly, CSF is found to be useful in IT evaluations that focus on identifying the requirements for the IT investments.

# Part III

# Analysis

This part contains an analysis of the usefulness of the methods as experienced in the case studies. A number of parameters, with relevance to choice of method, are identified and described. Lastly, the relationship between the parameters' attributes and the four selected methods are described and analysed. This is the basis of the framework.

# Chapter 7: Case study analysis

In this chapter the analysis of the five case studies is described. The focus is especially on identifying: (a) the methods' usability in different IT evaluations, and (b) the parameters that have influence on the choice of IT evaluation method.

The first part of the chapter identifies and describes the practical problems experienced in the completion of the four methods. This is not an essential part of the present dissertation but is included because it might give some input to what an IT manager from the construction industry needs to consider and emphasize when completing an IT evaluation. The description is enhanced by comparison with other sources.

The second part describes the strengths and weaknesses found in the five case studies. This, together with the description of the methods' theoretical strengths and weaknesses (see chapter 3), describes the methods' usability in different IT evaluations and can ultimately be used in the development of the framework (which is described in the following chapters). On the basis of the IT evaluations in the case studies, the preferred method is identified for each case study.

In the third part the case studies in Denmark are compared to two case studies completed in the UK. This is done in order to highlight some of the similarities and differences in completing IT evaluations in different countries.

In the last part of the chapter, the parameters that potentially have an influence on the choice of method, are identified. The parameters, together with those identified in chapters 2 and 4, will be used to develop the framework.

## 7.1 Practical problems experienced in completing IT evaluations

This section is partly based on a series of interviews with different IT managers (see the following Appendices B2, C3, D4, E4 and F4) that complete IT evaluations, and partly on the problems experienced in the case studies when using the four methods.

The problem most frequently mentioned by the IT managers in completing IT evaluations, was to identify the costs and benefits that can be associated with the IT investment. The impact from an IT investment influences the company's business activities in many ways which can be difficult to identify. Especially second order effects can be difficult to identify. This problem is worsened by the fact that the company's business activities are continuously undergoing changes, which makes it very difficult to identify which changes are caused by the IT investment. Similar problems have been reported by (Ballantine & Stray 1998).

In the case studies the process of identifying the IT investments' costs and benefits was, to some degree, found difficult and, in most of the case studies, it required several meetings before the final list of benefits was identified. The guidelines on cost and benefit identification from the three financially oriented methods provided very little help as they do not describe in detail how to complete this. The method, MBITI, however, provided more guidance than the other methods, because it has defined different business processes that can be used to identify the benefits.

Another aspect of this problem is to identify what to evaluate. As IT investments have a wide-ranging impact on the company it can, in some IT evaluations, be difficult to determine what to

include and what to exclude. This problem is also mentioned as one of the major problems, by (Hirschheim & Smithson 1999), in their description of why IT evaluation is difficult. They describe two aspects that are of importance when describing this problem. First, deciding what to measure especially as many of these aspects are highly intangible and, second, at which level is the evaluation performed (examples on different levels are: sector, firm, stakeholder etc).

This was not experienced to be a large problem in the case studies because, in the beginning, some effort was used on defining the IT investment to be evaluated. In the case study with Rambøll it was, however, found that the purpose of IT evaluation had changed. The choice was not difficult to make but it had a significant influence on the IT evaluation.

Another frequently mentioned problem in the interviews was to estimate the value of the measurable costs and benefits that are associated with the IT investment. In order to estimate the value of either costs or benefits it is necessary to predict the IT investment's future usage and other relevant changes that might occur in the company. This is indeed difficult for the IT managers especially if it has to be completed with a minimal amount of uncertainty. This was also identified as one the major problems in completing IT evaluations by (Willcocks 1994).

The quantification of costs and benefits was also found to be the most influential obstacle in the case studies, mostly when estimating the benefits. The difficulties in this activity were experienced in several ways. Often the estimates given were changed because the IT evaluation champion(s) felt that they were too uncertain, and therefore they had to identify and define the assumptions used to estimate the value of each benefit. The IT evaluation champion(s) often said that the estimates were imprecise even in those case studies where the benefits' assumptions were identified. Several of the case studies said that, in order to improve the precision of the estimates, a significantly longer time was needed. In the case study with Cowi it was decided to decompose the benefits into smaller fractions that were easier to estimate (see eventually Appendix C6). This did increase the precision of the benefits' estimates, but was also quite time consuming.

The estimates of the costs were, unlike the benefits, less frequently changed and therefore also found to be easier to estimate. In some of the case studies it was because most of the costs had already occurred whereas, in the other case studies, the IT evaluation champions were more experienced in completing the estimates.

A related problem, mentioned by an IT manager, is estimating the benefits that result in time savings and are not necessary accrued to the company but to the end users or the customers. This means that these benefit estimates are imprecise if this is not taken into account. A general assumption used in all the case studies, stating that time savings are resulting in cost savings, was therefore introduced in order to reduce the difficulties in estimating the time saving benefits (see eventually chapter 6).

One of the other IT managers mentioned that the objectivity of the estimates in most IT evaluations, is dependent upon the person giving the estimates. This means that IT evaluations can be used to pursue a political objective instead of providing a fully objective representation of the IT investment. (Powell 1999) identifies this aspect as well and emphasizes that the political influence should not be understated when completing IT evaluations.

Several of the IT managers said that completing IT evaluations was time consuming and that the time available is limited because quick decisions are often needed, which implies that a detailed evaluation is not possible. It was also mentioned that completing a detailed IT evaluation could be

costly, especially in post-implementation evaluations, and the costs could be higher than the benefits achieved from the IT investment.

The IT evaluations took significantly longer than expected in the case studies. This was strongly influenced by four out five case studies in all four methods being completed, instead of just one as was normally done.

One of the interviewed IT managers felt that it was a problem that the knowledge of available IT evaluation methods was poor. Little knowledge of both methods and how to evaluate IT investments, was limiting the company's IT evaluations.

## 7.2 Strengths and weaknesses of the four methods as experienced in the case studies

In the following, the four IT evaluation methods are described with regard to their strengths and weaknesses as experienced in the five case studies. Lastly some general comments on the IT evaluation methods are presented and discussed.

### 7.2.1 Net Present Value

*Strengths:*
NPV was, in all the four case studies where it was completed, experienced as relatively simple to use, mainly because it only uses one evaluation criterion (financial value). The method's need for data was relatively simple and the data required is either commonly available or relatively easy to derive.

The different IT evaluation champions in the case studies easily understood the method as it is commonly used in other types of evaluations. However, it requires a certain economic understanding because it uses economic concepts like rate of interest, etc. Cowi had earlier used a variant of the method in an IT evaluation and was therefore experienced with the method.

The output from NPV was found to be easy to interpret as it is expressing the directly measurable financial return of the IT investment. In H&S it was useful because it provided an easily comparable output, which was considered as an advantage when comparing different IT investments.

*Weaknesses:*
NPV provided a negative output in three out of four case studies, which means that 75% of the evaluated IT investments should not be approved according to this method. This is in contrast with the two other methods that provided more positive output. The primary reason for this is the method's focus on directly measurable costs and benefits, which excludes all the other types of benefit (e.g. the intangible benefits) that are included in the other methods.

Even though the method is easier to complete than the two other quantitative methods it still requires an identification and estimation of the costs and benefits that are associated with the IT investment. Especially these two tasks were considered as the most difficult in all the case studies. Using NPV in the IT evaluation still requires the completion of these difficult tasks, and the method cannot therefore be considered as significantly easier than the other two.

### 7.2.2 Measuring the Benefits of IT Innovation

*Strengths:*
MBITI defines different types of benefits and this was found to be a great help when identifying the impact of the IT investment in the different case studies. This method does not limit the type of benefits included in the IT evaluation (as opposed to NPV), as the three categories of benefit cover all possible types.

The method requires a moderate amount of time to complete mostly because the identification and estimation of the benefits was found to be time consuming. The extent of involvement is, however, small as one person on the tactical level (e.g. an IT manager) would be able to complete the estimation part alone.

The output from MBITI provides the user with a good insight into the impact from the IT investment on the company (see chapter 6). The output were considered as useful in those case studies where, either the purpose was to evaluate the impact from the IT investment, or to manage the IT investment.

*Weaknesses:*
Although MBITI is developed especially for companies in the construction industry it is not found to be a significant aid in the IT evaluations. The most notable element in the method, that can be related to the construction industry, is the definition of the 10 different business processes that are relevant to a variety of types of companies like: architects, consulting engineers, contractors etc. This was not experienced as a great benefit as most of the IT evaluation champions in the case studies had problems with interpreting the defined business processes. This was partly because they are poorly defined, and partly because they are a combination of the general business processes identified in both consultants and contractors.

Completing MBITI was, in several of the case studies, considered as troublesome because no explicit guidelines on how to complete the method were given. An overall description of the steps that need to be completed is given, but guidelines describing how each step should be completed are not included.

In all four case studies where MBITI was successfully completed, no benefits were categorised as belonging to the Effectiveness table. In the IT evaluation champions' point of view, benefits were either categorised as financially measurable or not measurable, whereas MBITI's categorisation of the benefits that are measurable (using non-financial quantities) was difficult to use. The problem was made worse because those benefits, that were originally categorised as effectiveness benefits, were re-categorised because of difficulties with estimating the necessary attributes.

Completing MBITI as a stand-alone method was found to be problematic as the method does not include the costs of the IT investment. This implied that the output provided by MBITI were regarded as insufficient in the case studies. However this can be avoided by completing a cost assessment as a supplement to MBITI.

Even though the post-implementation part of MBITI has not been directly a part of any of the case studies, it was found that the case studies considered this part as requiring much involvement. Therefore completing the whole method is regarded as requiring a considerable amount of involvement and resources.

During the completion of MBITI it was found that the three tables included were too small. It was therefore necessary to produce another table (an example of this can be seen in Appendix B5) in order to establish a proper overview of the identified benefits and their attributes.

MBITI was found to be difficult to use when comparing different IT investments because of the multiple output provided. The output from the efficiency table is comparable but will, in cases where different types of IT investment are evaluated, not be comparable. The performance table's output are not comparable even if the evaluated IT investments are the same type. This was evident in the case study with H&S.

Using the output provided by MBITI was also found to be useful in those case studies where the purpose was to get an overview of the IT investment. It was, however, experienced as less suitable for decision-making because of the difficulties in achieving an overview of the multiple output.

### 7.2.3 Information Economics

*Strengths:*
IE was completed in the four case studies where it was used successfully. The method was found to be capable of evaluating many different types of IT investment (there is, however, an exception to this, see the paragraphs describing the method's weaknesses).

The method was considered, by several of the IT evaluation champions in the case studies, as the best method because it reflected the characteristics of the IT investment in a holistic way, by evaluating three different domains. They also perceived the method as well-structured because of its logical structure and the usage of concepts enabling a more in-depth evaluation than some of the other methods.

In those case studies where the purpose was to compare different IT investments or to enable decision-making it was experienced as a useful method, mainly because it provides a good overview of the IT investment (by considering several evaluation criteria) and because it provides output that are easy to interpret.

*Weaknesses:*
In the case study with Rambøll, where the IT investment's primary objective was to automate some of the existing business activities, IE was found to be too complex because the use of evaluation criteria was too extensive (consider the metaphor of shooting mosquitoes with an elephant rifle). Even though the type of IT investment has an influence on how complex the method is, it was still experienced as over-evaluating the IT investment.

IE was found, in the case study with Cowi where the purpose of the IT evaluation was focused on managing the IT investment, less useful because it does not provide output that are suitable for this purpose. The output from IE are summary (this means that it express a static condition as opposed to formative output that express a dynamic condition), which reflects the status of the IT investment poorly and is a problem when managing the IT investment.

There was found to be difficult with the concept called Value restructuring because of its unrealistic data requirements. It was only applicable in the case study with H&S and, even in this case study, the IT evaluation champion expressed serious doubt about the precision of the estimates (the data) used in the concept.

An odd aspect of the method is the scale used for marking the ROI factor, which seems unreasonable because of the large intervals used, especially when evaluating IT investments in the context of construction. The consequence of this is that the IT investments' ROI factor received, in all four case studies, a mark of 1 even though there is a considerable difference in the IT investments' ROI factor. It is also considered as odd that this scale is defined independently of the lifetime of the IT investment.

IE was experienced as the most resource demanding method and requires considerable expertise to complete (this cannot necessarily be regarded as a weakness but is included because it might influence the choice of method). The method should ideally involve a business manager, a member from the IT department (or a person with knowledge of technology and the requirements of the IT investment) and the board of directors. The board of directors should, however, only be involved in defining the company weightings for the ten factors.

### 7.2.4 Critical Success Factors

*Strengths:*
CSF was found useful in one case study because it provided output that were useful in identifying the best IT investment. The list of critical success factors made it easier to identify whether the different IT investments fulfilled the requirements as stated by the stakeholders.

The method is relatively easy to complete as it does not require a special knowledge of how to complete IT evaluations. The interviewed stakeholders (from which the critical success factors are identified) from the case studies had no difficulty in answering the necessary questions in the interviews.

Although it is not a part of the method itself it allows a usage of many different IT evaluation criteria depending upon the critical success factors identified by the stakeholders. In one case study the cost of the IT investment was identified as an important factor. This does, however, not mean that a cost assessment is completed in the IT evaluation but that it is an important aspect of the success of the IT investment.

One of the significant strengths of CSF, as experienced in the case studies, is the involvement of the stakeholders in the IT investment. This showed the diversity of the stakeholders' requirements and enabled a better understanding of the multiple requirements of the IT investment.

*Weaknesses:*
The most significant weakness, as identified in the case studies, is that it cannot evaluate the cause-effect relationship of the IT investment (e.g. the financial benefits). In four out of five case studies the overall purpose of the IT evaluation was to evaluate the cause-effect relationship, and CSF was not able to provide perform such an evaluation. CSF was therefore not providing useful output in the majority of the case studies.

As the method is based on short interviews with different stakeholders, an extensive involvement from a variety of stakeholders is needed. This was found to be time consuming as a meeting had to be arranged with each of the stakeholders. Depending on how many stakeholders were interviewed in the case studies, it does involve some resources to complete the method.

CSF is very subjective and may be used to address political objectives in the IT evaluation. This was experienced in two case studies, Rambøll and H&S, where a stakeholder either had a predetermined attitude to the IT investment or had a previous experience that resulted in a change in

the criteria identified. This is not necessarily a bad thing, but may influence the method's output so that it can express more political objectives.

In several of the case studies it was found that the critical success factors identified by the stakeholders were focused on either implementation or usage issues. Only one stakeholder mentioned the IT investment's profitability as a critical success factor even though several of the case studies were focused on this criterion. A part of the reason for this is that at least one of the interviewed stakeholders in each case study was an end-user.

## 7.3 General comments on the IT evaluation methods

A significant conclusion, revealed in the previous section, is that none of the four methods can be considered as perfect in all possible IT evaluations, but each may have certain advantages in certain situations.

A common weakness of the first three methods (NPV, MBITI and IE) is the lack of guidance on how to identify the benefits of the IT investment. Very little explicit guidance was given on the methods. As previously described in this chapter, one of the obstacles experienced was to identify the benefits, and it would therefore be beneficial to have a guide or some instructions on how to perform this activity.

Another difficulty experienced was the estimation of the costs and benefits. The cost estimates were generally found to be easier to complete than the benefits. Estimating the benefits requires a very individual approach and it was found that some guidelines on how to perform this activity would improve the usefulness and accuracy of the methods. The estimates of the benefits in particular can, in some cases, be encumbered with so great an uncertainty that the estimates are useless in practice.

Not having guidelines for these two activities can, in extreme situations, make the IT evaluation very vulnerable to the IT evaluation champions' subjectivity, or to amending the data in order to achieve desired output for political reasons. If this is the case then many companies would argue that it is not worth the resources to complete an IT evaluation using formal IT evaluation procedures. It is therefore considered as very important that some guidance on how to complete these two activities is included in NPV, MBITI and IE.

The case studies also revealed that there were difficulties in interpreting some of the methods' definitions or concepts. This was especially valid for MBITI and IE. This problem reduces the usefulness of the methods and it may cause difficulties when completing them.

A common strength of the financially and quantitative oriented methods is that the focus is directed towards specific types of benefit. NPV focuses on the economically measurable benefits, and this means that the effort directed towards identifying and estimating these benefits may be increased because all other types of benefit are ignored. The same tendency can be identified in the other two methods but they require more than one type of benefit as input. By defining categories of benefit, they can direct the effort towards estimating the relevant attributes and thereby optimise the time spent on completing the IT evaluation.

The methods, that are quantitative (see chapter 2), are basically focused on evaluating the cause-effect relationship of the IT investment, whereas CSF is focused on identifying the requirements that have to be fulfilled in order to have success with the IT investment. The usefulness of CSF was found to be low in the case studies, because the primary purpose of four out of five IT evaluations was to evaluate the impact of using the IT investment on the company. Only one case study had the

purpose of identifying the necessary requirements for the IT investment. The purpose of an IT evaluation is found to be a very important criterion in selecting the best IT evaluation method, and this factor should therefore be given some weight.

## 7.4 Recommended IT evaluation method in the case studies

In this section the IT evaluation methods' usefulness in each of the case studies is discussed. The choice of the best IT evaluation method is primarily based on the description of the case study (see chapter 5), and the author's experience from completing the four IT evaluation methods, as described in chapter 6.

### 7.4.1 Rambøll

The best matching method from the IT evaluation is found to be MBITI. However, if the original purpose of the IT evaluation were taken into consideration (see eventually chapter 5), then it would have to be NPV, primarily because of the speed of this method.

MBITI is chosen as the best matching method in this IT evaluation primarily because it provides the IT evaluation champion and other decision-makers with a good overview of the IT investment's impact on the department (this is correlated with the second purpose as stated in chapter 5). This method is suitable when considering the company's current use of IT, but is considered advanced compared to the company's IT evaluation practice.

Using MBITI enables the IT evaluation champions to analyse the non-measurable benefits, which are considered as the main achievements of upgrading AutoCAD 14, even though the financial benefits are regarded as important, but they are not expected to contribute significantly to the IT investments' value.

### 7.4.2 Cowi

The best matching method in the case study with Cowi, is found to be MBITI. This is despite the measurement part of MBITI not being completed in this case study, even though this is a significant aspect of the choice of method.

The primary purpose of completing the IT evaluation in Cowi was to establish a monitoring plan that could be used in measuring the economical benefits. MBITI is the only method that includes that dimension of IT evaluation, and is therefore considered as useful in this context.

Through a completion of the method's first part, the IT evaluation champions can estimate the costs savings of the IT investment and this can be used to compare the expected and the measured benefits, which allows a comparison of whether the IT investment fulfils the expectations or not.

MBITI is also considered as a useful method considering the company's usage of IT and the current IT evaluation practice. Lastly it evaluates the non-measurable benefits of the IT investment that are an important part of the benefits achieved.

### 7.4.3 NIRAS

The most useful method in this case study, is CSF, not because it was the only method that was actually completed, but because it provides the company with a better understanding of the requirements for achieving success with the choice of projectweb strategy.

The primary reason why CSF is considered as useful in this case is because of the very early stage of the IT investment at which the IT evaluation is completed. The IT evaluation is therefore not an assessment of a specific IT investment, but an evaluation of the company's future strategy for using projectwebs. Identifying the critical success factors for the usage of a project web is therefore, in this context, considered as useful.

The company was not experienced as an advance user of IT and has a limited experience in how to complete IT evaluations, which means that the choice of method should be simple (CSF is considered as one of these).

If the purpose were to evaluate the cause-effect relationship of the projectweb strategy, then NPV would be the best matching method as it satisfies the requirements described in the previous paragraphs.

### 7.4.4 Højgaard & Schultz

In the H&S case study IE is argued to be the best matching method. The reasons for this choice are, first of all, that it is suitable for comparing different IT investments and second, because it evaluates the strategic value of the IT investment.

Completing IE provides two simple numerical output that are easily used when comparing different projectwebs, as is the case with IHD and ProjectNet. The method is furthermore providing output that identifies the ROI, strategic match and competitive advantage, which all are relevant in this IT evaluation.

IE is, however, not suitable when considering the company's usage of IT and its experience in completing IT evaluations. The match between the method and the actual requirements in the IT evaluation was still pointed to IE being the best method.

### 7.4.5 Troels Jørgensen A/S

In the last case study it is argued that MBITI is the most useful method, even though CSF is also considered as useful. The primary reason for the choice is that it provides output which increases the company's understanding of the IT investment's benefits, and this was the main purpose of the IT evaluation.

MBITI is a relatively easy method to understand for IT evaluation champions that have little experience and expertise in completing IT evaluations. The company's usage of IT is reasonably advanced making completion of a complex IT evaluation appropriate.

Although the company was mostly interested in evaluating the financial value of the IT investment, the method also evaluates the non-measurable benefits which, for this type of IT investment, are considered as a significant part.

## 7.5 IT evaluation in UK compared to Denmark

This section describes the output from three case studies completed during a six month stay at the University of Salford. MBITI was intended to be used on three case studies at: Costain, Taylor Woodrow and Alfred McAlpine.

The three case study companies are all contractors that have a higher turnover than even the largest Danish contractor. In that comparison the case study company, Højgaard & Schultz, is considered as a small company.

The case study completed with Taylor Woodrow was, however, not focused on using MBITI on a specific IT investment. The company had already adapted and amended the method, and therefore the differences between the original method and their version were analysed in order to identify how the original method could be improved. The work on comparing Taylor Woodrow's method with the original is not included or commented on in this thesis.

The two other case studies were primarily completed by the company's senior IT manager, a Ph.D. student from Salford University and the author. The IT evaluation is briefly described in the following for the two case studies.

### 7.5.1 Costain

The case study with Costain was focused on evaluating a pilot usage of an EDMS system called, Docs Open (for further information about this system see their homepage).

They had decided to test the EDMS system on a single building project placed in Uxbridge. The building project was a large shopping centre called The Chime located in the middle of the town (it includes a cinema). The tender sum was £70 million. The work on the building site started in November 1998 and was expected to be finished in February 2001.

Costain decided to evaluate the usage of Docs Open in order to be able to decide whether it should be used on all Costain's building projects. The primary purpose was therefore to identify (more precisely measure) the impact of the IT investment on the building projects' document management procedures. The IT investment was, at the IT evaluation time, already in use.

**Output from MBITI**

The data used in the IT evaluation was gathered during two meetings with several of the stakeholders. The output from the method, in the form of a questionnaire and three tables, can be found in Appendix G1.

*Table 18* shows in a summarised form the output from using MBITI on Docs Open.

*Table 18. Output sheet from MBITI (Costain)*

| Type of Benefits | Expected Benefits | Measured Benefits |
|---|---|---|
| Efficiency Benefits - Quantifiable and Financial | Total forecast monetary value<br>£188,918 | Total realised monetary Value |
| Effectiveness Benefits - Quantifiable but Non-Financial | Total forecast score / 100<br>100 | Total realised score /100 |
| Business Performance Benefits - Non-Quantifiable and Non-Financial | ▪ Competitive advantage A<br>▪ Supports IT strategy B<br>▪ Projection of company's business and IT strategy A<br>▪ Increased accuracy and reliability of information A<br>▪ Improved working relationship with client agents A<br>▪ Standardisation of software packages B<br>▪ Improved working relationship with design partners A<br>▪ Improved working relationship with subcontractors B<br>▪ Increased ability for users to focus on more value adding activities A<br>▪ Increased opportunity for end-users to improve IT skills A | |

Using Docs Open on the building project generates an estimated cost saving of £188,918 during the building projects' 28 months. This means, if this estimate is correct, that great cost savings can be expected if Open Docs is implemented company wide on all appropriate building projects. Some caution should, however, be taken when deriving conclusions on a company level.

Two benefits were categorised in the *Effectiveness table* and both were estimated as 100% likely to occur, which means the company expects to achieve the full potential of these benefits. The two benefits in this group are, when compared to the IT investment's overall value, not considered significant.

10 different performance benefits were identified, where the majority of these were rated as having a very significant impact and the rest as significant. Remarkably none of the performance benefits were rated either as moderate or low.

Overall both the efficiency and performance benefits are indicating that Docs Open is a valuable IT investment and should therefore be approved.

### 7.5.2 Alfred McAlpine

The IT investment that has been evaluated in the case study is a company intranet. The main objective is to enable the company's employees to get easy access to key information like corporate information, manuals, templates, company policies etc.

The IT investment is implemented company wide and will therefore enable the end user to get access to the intranet from any office. The graphic and website design was outsourced to a professional company but is, after the implementation, maintained and supported by the company's own staff.

The IT evaluation was initiated because the company wanted to analyse the how effectively the IT investment was utilised, but also importantly to identify new functions with which the company's intranet could be expanded in the future.

**Output from MBITI**

The data used in the IT evaluation was primarily retrieved from the senior IT manager during a period of 4 weeks, a few months before the system was implemented. A series of short meetings with relevant business and construction managers were also completed.

*Table 19. Output sheet from MBITI (Alfred McAlpine)*

| Type of Benefits | Expected Benefits | Measured Benefits |
|---|---|---|
| Efficiency Benefits - Quantifiable and Financial | Total forecast monetary value<br>£10,900 | Total realised monetary Value |
| Effectiveness Benefits - Quantifiable but Non-Financial | Total forecast score / 100<br>None identified | Total realised score /100 |
| Business Performance Benefits - Non-Quantifiable and Non-Financial | ▪ Controlled assess to budgets, forecasts and actual results A<br>▪ Access to corporate details for bids proposals B<br>▪ Access to up to date company performance data B<br>▪ Improved access to templates etc. A<br>▪ Access to construction information A<br>▪ Improved speed of access and consistency of important company information B<br>▪ Flexible system B<br>▪ Faster central access to key construction information C<br>▪ Faster and more reliable access to up to date H&S policies and information A<br>▪ Improved access to training availability B<br>▪ Improved advertising of staff vacancies C<br>▪ Bulletin boards which enable an improved company communication C | |

From *Table 19* it can concluded that the financial benefit is estimated at £7,900 which can be regarded as low. The direct cost of the IT investment is, however also small (the cost of the IT investment is not included in above estimate).

None of the benefits identified were categorised as effectiveness benefits.

The total number of performance benefits is 12 where 4 of them were rated as very significant (A), 5 were rated as significant (b), 3 as moderate and lastly none as low. The majority of the performance benefits are therefore rated at the high end of the scale.

Comparing the three rows in *Table 19* (see Appendix H1) reveals that it is the performance benefits that are dominating the overall impact of the IT investment.

The evaluation process using MBITI, confirmed that the system would, with a high degree of probability, meet the organisational requirements to be able to centralise and co-ordinate key construction and company information. Some financial savings are expected to be made by accessing information through the organisation's wide area network and the Internet, when compared to the paper systems they replaced.

### 7.5.3 Comparison of UK and Danish case studies

Based on the two UK case studies, upon which MBITI has been used, the strengths and weaknesses experienced are compared to those in the Danish case studies as described previously in this chapter. Lastly the usefulness of MBITI in the two UK case studies is analysed and described.

**Strengths and weaknesses**

In general the same strengths and weaknesses were found as in the Danish case studies when using MBITI.

Like the Danish case studies, the differentiation of the benefits into categories was regarded by the companies as a beneficial. However, the second table in the method was rarely used because most of the IT evaluation champions only differentiated the benefits into those that are tangible and those that are intangible. They found it therefore difficult to identify benefits that could be characterised as non-economically measurable.

The two case studies were either in the late implementation stage or in the usage stage, where the evaluations are focused on measuring the benefits achieved, and MBITI gives an advantage. The measurement of the achieved benefits was not completed in the case studies.

The two most time consuming and difficult tasks were the identification and estimation of the benefits (the costs were also analysed even though this is not a part of MBITI). One of the difficult questions was how to define usable measurement units that would reflect the realistic benefits when the actual measurement would be done. Completing these tasks was found to be difficult because no guidelines were given by MBITI.

**Usefulness of MBITI**

Overall it was experienced that MBITI provided a good understanding of the impact of the IT investment. The two case study companies saw this as a benefit in their future decision-making regarding the IT investment.

The case studies did, however, also reveal some weaknesses in MBITI like the poor use of the Effectiveness table.

## 7.6 Identification of influential parameters on the choice of IT evaluation method

The last section in this chapter contains the parameters that have been identified in the case studies as having an influence on the choice of the best matching IT evaluation method. The parameters were identified as having a direct influence on the choice of method in at least one of the completed case studies.

No specific data collection on identifying the parameters was completed in the case studies. This was primarily because the influential parameters should be identified through a "natural" completion of the methods. The advantage of this approach is that the identified parameters are found to be relevant in real-life IT evaluations, whereas the disadvantage is that the parameters that are important in other possible cases, are not identified. The disadvantage should be minimised (or eliminated) as the identification of the parameters is found by completing five independent case studies.

An alternative approach could have been to complete a series of interviews with different IT managers asking how they decided which method to use in their IT evaluation. This was, however, considered as a less useful approach. The IT evaluation practice in companies from the construction industry is in general poor, and their usage of formal IT evaluation procedures is very limited (as indicated in chapter 4). This means that most of the companies' IT managers are not, in their daily work, having to choose between a number of IT evaluation methods. The identified parameters would therefore not be based on their experience but rather on what they think should have an influence.

### 7.6.1 The identified parameters

In total 18 parameters have been identified as influencing the choice of IT evaluation method during the completion of the four methods in the case studies.

The means by which each parameter has been identified will not be described in this chapter as chapter 8 is devoted to this.

The 18 identified parameters are:

- Company size
- IT maturity
- IT evaluation practice
- Purpose of the IT evaluation
- IT evaluation criteria
- Format of output
- IT evaluation champions
- Users of IT evaluation
- Cost of IT evaluation
- Difficulty of IT evaluation method
- Type of IT investment
- Size of IT investment
- Purpose of IT investment
- IT investment domain
- Stage of the IT evaluation
- Importance of IT investment

All the listed parameters have, in at least one case study, been identified as influencing the choice of method and they are therefore useful in the development of the framework.

## 7.7 Summary

This chapter has described the analysis of the five case studies with regard to practical problems experienced, the strengths and weaknesses of each method and the choice of method. In the last part of the chapter a list of influential parameters has been identified.

*Table 20* shows the choice of IT evaluation method in each case study based on the case study descriptions in chapter 5 and the author's experience.

*Table 20. Choice of method in each case study*

| Case study | Choice of method |
|---|---|
| Rambøll | MBITI |
| Cowi | MBITI |
| NIRAS | CSF |
| Højgaard & Schultz | IE |
| Troels Jørgensen A/S | MBITI |

A number of parameters relevant when choosing an IT evaluation method, were also identified.

- Company size
- IT maturity
- IT evaluation practice
- Purpose of the IT evaluation
- IT evaluation criteria
- Format of output
- IT evaluation champions
- Users of IT evaluation
- Cost of IT evaluation
- Difficulty of IT evaluation method
- Type of IT investment
- Size of IT investment
- Purpose of IT investment
- IT investment domain
- Stage of the IT evaluation
- Importance of IT investment

# Chapter 8: Identification of the influential parameters

This chapter summarises the parameters that have been identified as influencing the choice of IT evaluation method. The parameters are identified through: (a) a theoretical analysis of how the methods can be characterised (see chapter 2), (b) the questionnaire survey (see chapter 4) and (c) through an empirical investigation of which parameters are influencing the company's IT evaluation and the choice of method (see chapter 7).

The first part of the chapter describes a way of categorising the identified parameters. Three groups of parameters are identified and defined so they represent different aspects that are of relevance when choosing the method. The second part describes how each of the parameters was identified as relevant. In the case that a parameter is identified through several sources this is described as well.

The identified parameters will be used in the framework as described in chapter 9.

## 8.1 The categorisation of the parameters

The parameters identified as influencing the choice of method are primarily based on two aspects where, (a) the methods' characteristics and (b) the parameters identified in the survey and the case studies in combination, are influencing the choice of IT evaluation method.

In total 21 parameters were identified as influencing the choice of method. The parameters are not defined in this chapter (see instead chapter 9) even though this is considered as relevant. The combined list of parameters is shown in *Table 21* in relation to their source.

*Table 21. List of identified parameters*

| Theory | Survey | Case studies |
|---|---|---|
| Decision process | Company type | Company size |
| Relation of project to business | Company size | Company position |
| Leadership role | | Business strategy |
| Industry situation | | Role of IT |
| Company size | | IT maturity |
| IT evaluation criteria | | IT evaluation practice |
| Format of output | | Purpose of the IT evaluation |
| Level of evaluation | | IT evaluation criteria |
| Type of IT investment | | Format of output |
| Type of impact | | IT evaluation champions |
| Scope of IT evaluation method | | Users of IT evaluation |
| Stage of IT evaluation | | Difficulty of IT evaluation method |
| | | Type of IT investments |
| | | Size of IT investment |
| | | Purpose of IT investment |
| | | IT investment domain |
| | | Stage of IT evaluation |
| | | Importance of IT investment |

Most of the listed parameters have been identified in the case studies, whereas 12 parameters have been identified as relevant characteristics when describing the IT evaluation methods (see chapter

2). Some of the parameters are listed several times simply because they have been identified from more than one source.

By analysing the identified parameters listed in the table, three groups can be identified: *Company*, *IT evaluation* and *IT investment*. The three groups each represent an important influence on how IT evaluation methods are chosen.

The first group of parameters is referred to as *Company*. Generally the parameters defined in this group are related to the characteristics of the company that wants to complete an IT evaluation. A number of the parameters in this group are static, meaning that they do not change radically over time.

The second group of parameters is called *IT Evaluation*. This group is related to the process of IT evaluation. All the parameters, that have something to do with how the IT evaluation is completed, are defined in this group. These parameters are considered as dynamic in this group, meaning that they have to be adjusted to the company's current IT evaluation.

The last group of parameters described is related to the *IT Investment*. These describe the characteristics of the IT investment to be evaluated. They are also dynamic of nature.

Rearranging the parameters in their corresponding groups is shown in *Figure 35*.

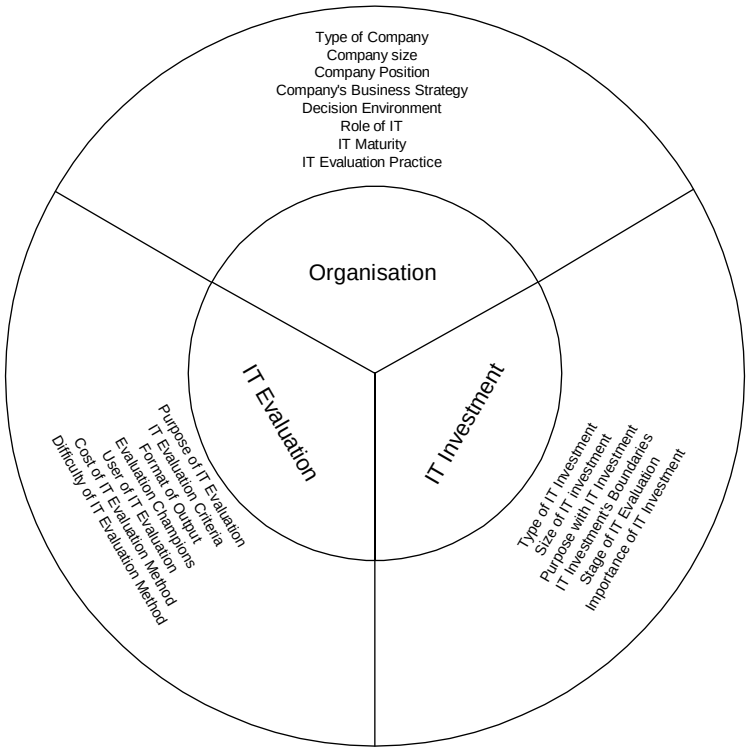



*Figure 35. Parameters used in the framework*

## 8.2 Company parameters

The first group of parameters are derived from the characteristics of the company performing the IT evaluation. The parameters identified in this group are not directly related to the IT evaluation or the IT investment.

Nine parameters have been identified (see eventually chapter 2, 4 and 7) as belonging to this group.

- Company type
- Company size
- Company position
- Business strategy
- Decision environment
- Role of IT
- IT maturity
- IT evaluation practice

### 8.2.1 Type of company

In chapter 4 it was revealed in the analysis of the questionnaire survey, that the type of company has influence on the company's IT evaluation practice and therefore also on its choice of IT evaluation method. It was found that contractors rely more on informal IT evaluation procedures than both architects and consulting engineers.

The type of company may potentially have influence on the choice of IT evaluation method because of the characteristics of their main business activity in the company culture. For example the products or services offered by a company will have influence on the type of data available in completing the IT evaluation. An example is that it is common that consulting engineers register the time spent on a project (which is then included in the customer invoice) and this can be used as data in an IT evaluation for this type of company. They also charge out their use of IT, for example, by invoicing the cost per CAD drawing.

### 8.2.2 Company size

In the survey described in chapter 4 it was concluded that the company's size has influence on how they complete IT evaluations and therefore on the choice of method. It was also revealed that the frequency of IT evaluations in small companies was lower than for large companies, and that they tend to use more informal IT evaluation procedures than both the medium and large companies.

The influence of company size was also identified in the case study with TJAS (see chapter 7), where the complex methods were criticised for being too impractical, whereas the other case study companies did not mention this as a problem.

### 8.2.3 Company position

This parameter's influence on choice of method is recognised by (Farbey, Land, & Targett 1993), where they argue that the IT evaluation is likely to be exploratory if the company's position is highly based on being the "best", whereas other companies can be guided by existing investments by the leading companies, which give the decision-makers some comparison and might provide data they can use in their own IT evaluation.

In the case study companies different positions were identified (see chapter 9), and it was also found that these had an influence on the choice of method. The case study companies (Rambøll,

Cowi and H&S) that had the objective of being the best in their business were also more focused on methods that are capable of evaluating the IT investments' competitive advantage, whereas the other case study companies were more interested in, for example, the cost savings.

The choice of IT evaluation method is influenced by this parameter because the company's position requires an adjusted focus on the IT investment's competitive value.

### 8.2.4 Business strategy

All five case study companies have a cost-oriented business strategy (beating the competitors on price) because this was found to influence the completion of the IT evaluations. They were all interested in those methods that used a financial evaluation criterion, and which produced output that expressed the IT investment's profitability, rather than focusing on how they could provide different products or services.

This parameter is relevant because it has a significant impact on the company's current and future use of IT. The business strategy contains the overall directions of why and how the company should perform its activities in the long term. Many companies increasingly consider IT as one of the important enablers of the business strategy, and are therefore influenced greatly by it. In general the company's business strategy will reflect what kind of IT investments are desirable for the company.

### 8.2.5 Decision environment

The importance of the decision environment when choosing a method is recognised by (Farbey, Land, & Targett 1993) (this is also described in chapter 2). They argue that the chosen method must conform to the company's existing corporate appraisal procedures or, if there is no established practice, it must be able to adapt to imported or ad hoc methods.

This parameter is relevant because a company's decision environment, and therefore its standards and procedures for how to make decisions, is a part of the IT evaluation. If the IT evaluation method does not support the accepted ways of making decisions, then the IT investment, no matter how good or bad, will be rejected because of the wrong decision making process.

### 8.2.6 Role of IT

This parameter was identified in the case studies because of the way the companies currently use their IT, and their future expectations had an influence on how important the usage of IT is. NIRAS had a very visible perception of how important the usage of IT was to the company, and it was found that this influenced the choice of method by limiting the number of methods because some were not relevant.

The parameter, Role of IT, has influence on the choice of IT evaluation method because it will reflect the importance of completing the IT evaluation. It is considered relevant because the company's way of using IT will reflect its need for making sure that the IT investments implemented are indeed the most promising ones.

### 8.2.7 IT maturity

The importance of this parameter was experienced in the case studies (see chapter 7) where the companies' IT maturity had an influence on the choice of method. It was found that those companies that have a relatively high IT maturity were also those that were capable of using the complex methods.

The IT maturity is relevant because it reflects the company's capability of implementing and using IT. Another effect of the company's IT maturity level is the increased ability to complete more complex IT evaluation methods as they have a greater understanding of the company's IT usage.

### 8.2.8 IT evaluation practice

The case study companies' IT evaluation practice was found relevant when considering how complex and difficult the method chosen should be. For example, in TJAS, the company's IT evaluation practice was found to be very ad hoc, which meant that the company was not experienced enough to use the more advanced methods.

A company's IT evaluation practice expresses how much experience and skill in completing IT evaluations it has. The more experienced and skilled the more complex methods can be used.

## *8.3 IT evaluation parameters*

The second group of parameters is derived from the characteristics identified from the IT evaluation. This group of parameters is, by definition, only related to issues in the process of the IT evaluation itself.

Seven parameters have been identified throughout the previous chapters.

- Purpose of IT evaluation
- IT evaluation criteria
- Format of output
- Evaluation champions
- User of IT evaluation
- Cost of IT evaluation method
- Difficulty of IT evaluation method

### 8.3.1 Purpose of IT evaluation

The different IT evaluation purposes that were identified in the case studies were not equally well supported by all four methods. One case study (H&S) company wanted to identify the most promising IT investment, whereas another (Cowi) was interested in measuring the achieved benefits, etc. The choice of method was therefore found to be dependent upon the IT evaluation's purpose.

In general the purpose of the IT evaluation is crucial in this choice of method. Why complete an IT evaluation by using a method that is not able to fulfil the purpose? It would not make sense if the method could be chosen without considering this parameter.

### 8.3.2 IT evaluation criteria

In chapter 2 this parameter was identified as important because the available methods use a variety of evaluation criteria and, in order to choose an appropriate method, the IT evaluation champions need to identify which criteria are important.

Many different criteria were used in the evaluation of the IT investments in the case studies and these were found to influence the choice of method, primarily because some methods are regarded as good for evaluating the financial value, others for identifying the requirements, etc. (see chapter 2).

This parameter is, in most cases, very important for the choice of IT evaluation method as very few, if any, methods cover all possible criteria. The choice of criteria determines the value of the IT investment to the company in that IT evaluation. This may not reflect the true value but rather how the company views the value of the IT investment.

### 8.3.3 Format of output

This parameter was identified in chapter 2 where it was used to characterise the methods. It influences the choice of method when the IT evaluation champions have to decide which aspects of the IT investment they wish to evaluate, as this will imply some requirements for the methods' output.

In several of the case study companies, the output provided by the methods influenced the usability of the method because the case study companies had different needs for output. For example Cowi wanted to identify how to measure the benefits, which meant that the method's output should provide such an opportunity.

The format of the output provided by the methods has an influence on how the IT evaluation can be completed so that it supports the needs of the company. It also enables the companies to determine what aspects of the IT investment they want to know more about, for example the financial value, quality improvements, etc.

### 8.3.4 Evaluation champions

This parameter is partly identified in the parameter called, *Level of evaluation*, in *Table 21* which, in chapter 2, was to used to characterise an IT investment. It has an influence on the choice of method because each method has it own specific data requirements that might make it unsuitable for some IT evaluation champions and suitable for others.

It was not only IT managers that conducted the IT evaluation in the case studies. For example in H&S an end user, who had an expert knowledge, completed the IT evaluation whereas in another case study (Cowi) the IT evaluation champions consisted of several persons, representing different levels in company from the strategic to the operational. The evaluation champions have, depending on which level of the company they belong to, different access to data and have different perceptions of what are the most important issues when evaluating the IT investment, and this was found to influence the choice of method.

This parameter is relevant because the level at which the IT evaluation champion(s) is/are placed implies different needs for the chosen IT evaluation method. The choice of IT evaluation method might not always be influenced by this parameter but, in some cases, it is an important parameter.

### 8.3.5 User of IT evaluation

This parameter is the second part of the parameter called, *Level of evaluation*, in *Table 21*. The different available methods might be useful to some levels of the company, whereas others might consider the methods as less useful.

Related to the previous parameter the users of the output provided by completing the IT evaluation also influenced the choice of method. Depending upon which level of the company was using the output of the IT evaluation, different requirements were chosen, for example in one case study (Cowi), the IT evaluation was required by the board of directors who wanted to know how much

saving the IT investment generated. This meant that the choice of method was partly influenced by the user of the IT evaluation.

This parameter is relevant because the user of IT evaluation output will require a different format and a different type of output. The different requirements are primarily related to what the user wants to use the output for.

### 8.3.6 Cost of IT evaluation method

Especially NIRAS was concerned about the cost of completing the IT evaluation because the company did not want to spend too many resources on this activity (see chapter 7). Cowi was, however, not severely limited by the cost of the IT evaluation as some money was allocated to this activity. The choice of method was therefore found to be influenced by how costly the method is.

The cost of IT evaluation is relevant because the resources spent on completing the IT evaluation need to be proportional to the cost of the IT investment itself. For example when buying a new printer it would be too much to try to evaluate the IT investment with a very expensive method. This could, in an extreme situation, mean that it would require significantly more resources than the IT investment was costing itself. Alternatively a very expensive IT investment might imply that a higher cost of IT evaluation is allowed.

### 8.3.7 Difficulty of IT evaluation method

This parameter was identified in several of the case studies. In two of the case studies (Rambøll and TJAS) the IT evaluation champions said the preferred method should be a simple, fast and practical which are all related to how difficult the method is to complete. This implied that the more complex and time-consuming methods were not selected.

This parameter is relevant because the difficulty of the method is important for usability of the method and success in the IT evaluation. Choosing one with a high level of difficulty might result in the usage of a complex method which the company cannot complete satisfactorily because of lack of expertise. The IT evaluation will probably be considered as a failure because of this. The opposite situation could also occur if the company chose too simple a method that could not produce the useful output that the company actually wants.

## *8.4 IT investment parameters*

The last group of parameters focuses on the characteristics of the IT investment that is evaluated. This group of parameters is, by definition, only focused on issues related to the IT investment itself.

Six parameters have been identified throughout the previous chapters.

- Type of IT investment
- Size of IT investment
- Purpose of IT investment
- IT investment's domain
- Stage of IT evaluation
- Importance of IT investment

### 8.4.1 Type of IT investment

In chapter 2 this parameter was identified as relevant when describing the methods. It was mentioned that the available methods are better for evaluating some IT investments than others.

This means that the choice of method should be determined by the type of IT investment evaluated. The parameter called, *Relation of project to business* (see *Table 21*), is also relevant in this context.

The choice of method was also found to be dependent upon the type of IT investment. Completing the four methods in the case studies clearly showed that some methods are better than others when evaluating different IT investments (see chapter 7). An example is the case study with Cowi where the IT investment was characterised as strategic. This type of IT investment required a more complex method that is capable of evaluating several aspects.

The type of IT investment is relevant when choosing the IT evaluation method because certain characteristics of the IT investment can be used to select between the available methods, so that the chosen method is more capable of evaluating it. An example is IT investments that solely focus on automating some existing working procedures, which, in most cases, can be evaluated satisfactorily by using a financial IT evaluation method like NPV.

### 8.4.2 Size of IT investment

The influence on the choice of method from this parameter was identified in the completion of the case studies (see eventually chapter 7). The influence was especially experienced in two contrasting case studies. The first case study (Cowi), where the IT investment required a high level of resources compared to IT investments usually undertaken by the company. This influenced the choice of method by aiming at more detailed and complex methods. The other case study (NIRAS) evaluated an IT investment that required a low level of resources compared to other IT investments in the company, and resulted in the choice of method being focused on those that provided less detailed output.

In general the size of the IT investment was found to be relevant when considering how high a level of detail the method was able to handle.

### *8.4.3* Purpose of IT investment

As mentioned in chapter 2, it is argued that not only the type, but also the purpose, of the IT investment have an influence on which method should be used (this parameter is called, *Type of impact*, in both chapter 2 and in *Table 21*). This is because some methods are considered better for evaluating some impacts whereas others are good for evaluating other impacts.

This parameter's influence on the choice of method was also experienced in two case studies (NIRAS and H&S) where the same type of IT investment was evaluated, but the purpose of the IT investment was different. In all five case studies the purposes of the IT evaluation were found to be important in the choice of method.

The purpose of the IT evaluation will have a significant influence on the choice of method, as different IT evaluation purposes require, for example, specific formats of output. For example,, if the purpose is to identify the best IT investment, it would be beneficial if the chosen method provides simple and easy comparable output whereas, if the purpose is to identify the impact from the IT investment, the most useful output represent multiple effects.

### 8.4.4 IT investment's domain

This parameter is, in chapter 2, referred to as the scope of IT evaluation method but is renamed in this chapter because it can be related to the parameter with the name, IT investment's domain,

which was identified in the case studies. It is relevant because the domain of the IT investment implies different requirements for the chosen method.

The different domains of the IT investment were found to influence the choice of method mainly because some are developed especially for use in companies and others for a building project. The earlier domain was relevant in the case study with Cowi, and the latter in the case study with H&S.

The choice of IT evaluation method needs to be able to support the IT investment domain or else the use of the method would be problematic, and would, in most cases, produce output that are less usable. The IT investment domain will therefore have to be identified in order to choose the methods that support such an IT evaluation.

### 8.4.5 Stage of IT investment

The parameter, *Stage of IT investment*, was identified as influencing the choice of method in chapter 2. Some methods can, with advantage, be used ex-ante whereas they are useless in ex-post evaluations and vice versa. Few methods are usable in both ex-ante and ex-post evaluation. The stage of the IT investment therefore influences the choice of method.

In all five case studies several different stages of the IT investments were identified and this was found to influence the choice of method. In NIRAS the IT investment was at an early stage where the choice of projectweb strategy was about to be decided. The stage of the IT investment was found to affect the choice of method, primarily because the availability of data needed for an IT evaluation was very sparse.

The stage of the IT investment influences the choice of method in two ways. Firstly, because some IT evaluation purposes are more relevant than others at certain stages. Secondly, the data available for the IT evaluation varies depending on the stage of the IT investment.

### 8.4.6 Importance of IT investment

The last parameter found in the case studies (see chapter 7) as having an influence on the choice of method, is the IT investment's importance to the company. This was, for example, experienced in the case study with Cowi where the IT investment was regarded as very important, and they were therefore interested in a method that provides a more in-depth analysis.

The more important the IT investment is to a company the more likely it is that the requirement for the choice of IT evaluation method is complex. This might affect the company's allowance of cost for completion of the IT evaluation, and requirements for the level of detail of the output provided by the method.

## 8.5 Summary

In total 21 parameters, that have an influence on the choice of IT evaluation methods, have, in this chapter, been described with regard to the source from which they have come. The parameters were furthermore identified as belonging to one of three groups.

*Table 22. The three groups of parameters and the related parameters*

| Company | IT evaluation | IT investment |
|---|---|---|
| Company type | Purpose of IT evaluation | Type of IT investment |
| Company size | IT evaluation criteria | Size of IT investment |
| Company position | Format of output | Purpose of IT investment |
| Business strategy | IT evaluation champion(s) | IT investment's domain |
| Decision environment | User of IT evaluation | Stage of IT evaluation |
| Role of IT | Cost of IT evaluation | Importance of IT investment |
| IT maturity | Difficulty of IT evaluation | |
| IT evaluation practice | | |

# Chapter 9: Description of the parameters

In chapter 8 three groups of parameters were identified as relevant when describing how to choose an IT evaluation method. In this chapter each of the parameters, as identified in chapter 8, is defined and described. The parameters are expanded by defining a series of attributes relevant to each of the parameters.

In the first part of this chapter each of the parameters identified is defined and analysed according to the various attributes that are assigned to it. These attributes are then described. The parameters and their attributes will be used to form the basic structure of the framework for how to select the best matching IT evaluation method. Additionally the five case studies are described in relation to each parameter's attributes. These descriptions will, in chapter 11, be a part of the data used to test the framework.

Lastly, the parameters and their attributes' potential overlaps are described. Firstly, the parameters' potential overlap is described with regard to the parameters within its own group and secondly, with regards to the parameters in the other groups. The potential overlap between the parameter's attributes is, as described in chapter 10, used to check the consistency of the IT evaluation description.

## *9.1 Company parameters*

Eight parameters were identified in chapter 8 as belonging to the group called, *Company*. Each of these is defined and a series of attributes, that represent the parameters' different possibilities, are defined.

### 9.1.1 Type of company

The first company dependent parameter is called, *Type of company*. It is defined as the business activity that can best describe a company's main occupation. This parameter is also used widely in other contexts to characterise a company's main activity.

Several types of company can be identified in the construction industry and a few these are listed below. The list is not complete and it should be recognised that both additional groups and various subgroups could also be mentioned, but the fact that these are included is not considered as more beneficial.

- Building material supplier
- Architect
- Consulting engineer
- Contractor

Each of these types of company represents certain characteristics that potentially have an influence on the choice of IT evaluation method. The characteristics used to define the attributes are: (a) main business activity, and (b) the typical company culture related to the main business activity.

The attributes are defined in the following:

- **Building material supplier**
  Companies of this type produce building material like, for example, prefabricated concrete

elements, windows, bricks etc. The main business activity is therefore producing building material, which can be characterised as standardised, and where the production process is the same for each unit produced.

The related company culture is mass production of building material in factories where one of the advantages is the repeated production process. In general the production process is highly standardised which increases efficiency, and the business activities can therefore be considered as highly measurable using relevant standardised measures.

- **Architect**
  These companies are mainly occupied with planning and design of building projects of any type. They are often involved in the earlier stages of a building project when the design and specification are completed.

  The company culture can be described as project based, where very little earlier work can be reused because a significantly amount is based on creativity and uniqueness. The company is typically hired to complete the initial planning and design of the building project, and the payment is based on a fee.

- **Consulting engineer**
  Companies of this type offer consulting and planning of building projects of any type. They are often involved in the building project's design phase where they do the technical calculations. The main business activity is consultancy and planning.

  In general the company culture in consulting engineer companies is not much different from architects. The work is primarily project based and the payment is based on a fee.

- **Contractor**
  The actual building of the projects is the main business activity of this type of company. They construct several types of project such as bridges, roads, offices, houses, etc. Two categories of contractor are common: general contractors and specialists contractors (these are not included in the framework).

  The company culture is also based on projects, but they are won on the basis of tenders including the whole value of completing the building project. This is radically different from architects and consulting engineers and means that the company's economy is handled differently from that in the two previous types of companies.

It is today common that some companies (typically larger companies) perform several of the business activities described and many attributes should therefore be valid. Despite this it is argued that most IT investments can be related to one of the business activities mentioned above, and therefore only one attribute can be valid at a time.

### 9.1.2 Company size

This parameter describes the size of the company that conducts an IT evaluation. Size is, in this context, defined as the number of office workers. This is primarily because some companies have a significant amount of hourly-paid employees (especially contractors), and others might have long-term employees (who are typically paid monthly).

The parameter's attributes are divided into three ranges that cover all the possible sizes of company.

- **Small**
  The first range is defined as including all companies that have 1 to 19 office workers. In the Danish construction industry this includes most of the building material suppliers, the majority of the architect firms and a significant proportion of the local consulting engineers and contractors.
- **Medium**
  Medium-sized companies are defined as including companies that have 20 to 99 office workers. The total number of companies within the four defined groups (see the previous parameter) is significantly lower than the number of companies categorised in the previous range.
- **Large**
  This range defines the size of companies as including those which have 100 or more office workers. The total number of companies in this category is very small compared to the two previous ranges. Building material suppliers are most widely represented in this range.

Only one attribute can be valid, as the definitions are mutually exclusive.

### 9.1.3 Company position

Besides company type and size the company's position in the competitive market influences the choice of IT evaluation method as identified in chapter 8. The company position is, in this context, focused on whether the company wants to be the "best" (many criteria can mean the "best" such as the largest, most profitable etc.), or that the company wants to be among the best companies but not *the* best or, lastly, that they simply want to do business without aiming to be better than the others.

The following attributes are used to describe the three possible positions a company can occupy.

- **Leader**
  In this position the company considers itself as being (or aiming at being) the leader in conducting its business activities. In a strict sense this implies that only one company in a defined business area can be successful however, as mentioned earlier, there may be many different definitions on how to be the "best". Being (or aiming at being) a leader often requires extra resources.
- **Follower**
  Companies pursuing this position are not aiming at being *the* leader but they want to be among the best. Being among the best companies in a business area requires some resource but not as many as in the previous attribute.
- **Lagger**
  The last attribute includes all companies not categorised in the two first. Laggers are companies that are not aiming at being *the* leader or among the best companies, but they are rather "surviving" and simply doing business. Little or no resources are spent on improving their current position.

The three defined attributes are mutually exclusive implying that only one attribute can be valid.

### 9.1.4 Business strategy

Two aspects are included in this parameter, first the company's competitive advantage, and second the market sector. A company's competitive advantage is either based on competing on cost or by

providing different products or services, and a company's market sector can either be broad or narrow.

The different business strategies used by companies can be characterised by Michael E. Porter's work on defining four generic strategies (Porter 1985). The generic strategy framework is illustrated in *Figure 36*.

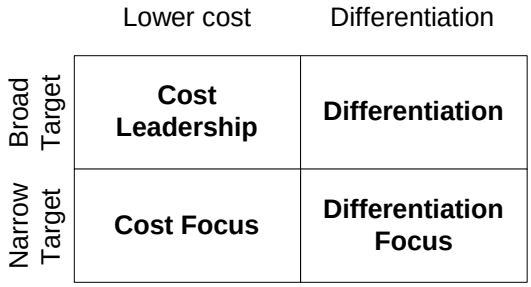



*Figure 36. M. E. Porter's four generic strategies (Porter 1985)*

Theoretically there is a fifth opportunity that could be called, *No strategy*. This strategy is, in practice, not relevant to consider, as a company would not be able to survive in the long-term by using it.

- **Cost Leadership**
  Companies using this strategy are targeting a broad market sector and offer services or products that other companies also offer. The companies compete therefore on being *the* low-cost producer. An example could be MT Højgaard A/S (the largest contractor in Denmark). They are involved in all types of building project and primarily compete by giving the best tenders.
- **Differentiation**
  If companies are using this strategy they are aiming at offering unique services or products to a broad market sector. Unique means, in this context, services or products no one else can offer. Companies using this strategy compete on uniqueness of services or products. An example of such a company is Velux that specialises in producing roof windows.
- **Cost Focus**
  The third generic strategy is about targeting a narrow market sector offering cost-effective services or products. The aim is to be *the* low-cost producer of services or products to a small group of customers. Companies, like Spæncom, that produces prefabricated elements, is as a good example of a company using this strategy because they compete on price but target a narrow market sector.
- **Differentiation Focus**
  The last generic strategy identified is also targeting a narrow market sector but by offering unique services or products. Companies using this strategy are aiming at delivering special services or products to a small group of customers that no one else can offer. An example of a company using this strategy could be Demex that offers specialist consultancy on re-use of building materials.

It is important to stress that a company's different business units (e.g. divisions) can pursue different generic strategies, and this therefore implies that a company can use more than one generic strategy. Those companies that in general pursue all four strategies, might get stuck between them and therefore increase the risk of not being successful with any of them. It is, however, argued that

one generic strategy can be identified as the most important in the context of the IT investment, and therefore only one attribute can be valid.

### 9.1.5 Decision environment

This parameter is called decision environment and addresses the company's culture and procedures for how to make decisions related to IT. The question is whether the company has rigorous standards and procedures for how to produce and present the information upon which decisions have to be made, or is it up to the IT investment champion to decide.

This parameter's attributes can range from highly standardised ones using written procedures to oral and subjective guidelines that may change from time to time. There may, however, also be other attributes lying between the two mentioned, for example, general guidelines that can be expanded/amended if needed.

The attributes for this parameter can be defined as follows and cover the possible decision environments which can be identified in a company.

- **No standards or procedures**
  Companies with a decision making environment, where there are no standards or procedures to be followed when making IT related decisions, choose this attribute. It implies that decisions related to IT investments are taken by any appropriate person using an ad hoc approach.
- **General guidelines that can be expanded/amended**
  In this attribute companies have general guidelines that can be expanded/amended if necessary. These companies have, to some degree, formalised the decision making environment, which might have an influence on how decisions about IT are taken.
- **Written standards and procedures that have to be followed**
  The last attribute is for companies that have written standards and procedures for how the decision process should be executed. The decision making environment is highly formalised and there is no doubt about how the decision process should be structured and what procedures should be used.

The three attributes defined are useful for describing most companies' decision making environment. One attribute can be identified as the best match and therefore only one attribute can be valid.

### 9.1.6 Role of IT

How important is IT to the company? This parameter focuses on the company's usage of IT in terms of strategic importance now and in the future. Strategic importance means, in this context, how dependent and influenced the companies' core business activities are by using IT.

This can be described by using McFarlan & McKenney's strategic grid which displays the role of IT in a company (McFarlan & McKenney 1983). *Figure 37* shows the diagram used to categorise the role of IT in the company.

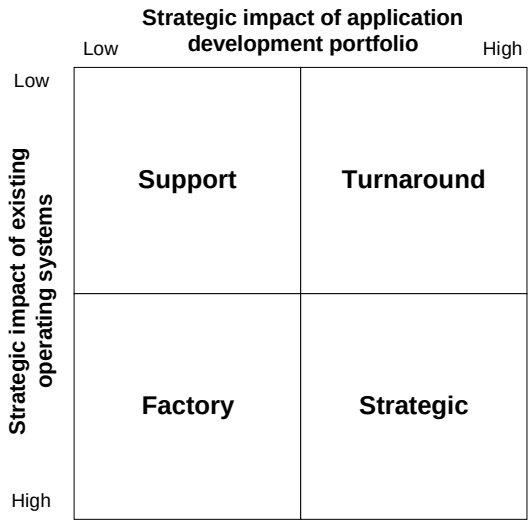



*Figure 37. Role of IT using the strategic grid (McFarlan & McKenney 1983)*

*Figure 37* shows a matrix with two dimensions: *Current impact* (the vertical axis) and *Future impact* (the horizontal axis). The dimension *Current impact* is about how important IT is for the company in order to operate its business activities today. The other dimension, *Future impact*, is about how great an influence IT will have on the company in the future. Both of the dimensions use a scale from low to high. The grid is divided into four different squares each representing a characteristic.

- **Support**
  The upper-left square, called support, is characterised by a low dependency and impact of IT both today and in the future. This is typical of a company that does not use IT in its core business activities, and the use of IT does not have a significant impact on what the company is doing. An example of such an organisation is a cement factory.
- **Turnaround**
  The upper-right square is characterised by a low dependency and impact on the company's current business activities and a high impact of IT in the future. The companies in the factory square are not dependent on IT but it has a potentially significant impact on business operations. Retailers are usually placed in this square.
- **Factory**
  This square has the opposite characteristics to the previously described square, meaning a high dependence on, and impact of, IT today, and a low impact in the future. The company in this square typically uses IT in its core business activities, but it does not have a significant impact in the future. An example of a company in this area is a steelworks.
- **Strategic**
  The lower-right square, called strategic, is characterised by high dependency on, and impact of, IT both today and in the future. This implies that the company's usage of IT is, and will in the future, have a high priority, and a significant focus on IT investment can be expected. An example usually placed in this square is a credit card company like MasterCard.

The attributes defined in this parameter are mutually exclusive, which means that only one of them can be valid. All the possible uses of IT in the company can be identified by the defined attributes, and therefore one attribute can describe the company's usage of IT.

### 9.1.7 IT maturity

The IT maturity in the company will also influence the choice of IT evaluation method. IT maturity in a company is defined as the planning and integration of IT into the company's business activities. This includes the company's capabilities for using and integrating IT, the strategic usage of IT and the employees' abilities in using IT.

The parameter's attributes are defined using a scale from "*An IT Self-Assessment tool*" published by Construct IT (Construct IT 2000). In this framework 6 levels have been defined and these are described in the following.

- **Not applicable**
  At this maturity level a company does not use IT to support its business processes. It is therefore not possible to identify these companies' IT capabilities because no experience in using IT exists. The company's IT maturity level means that it has little capability to implement new IT systems.
- **Occasional**
  A company has, at this level, little understanding of the value and potential of IT because of low consistency in its IT use. The use of IT is without overall guidelines. The company is dependant on individuals fulfilling their own needs for hardware and software and does not have a common strategy for its IT usage.
- **Responsive**
  At this level a company's IT implementation is governed by competitors or software upgrades from software vendors. The company's use of IT is primarily driven by a technology push rather than a technology pull. IT investments are mainly undertaken and used when asked for by clients and partners.
- **Planned**
  A company has, at this level, plans for their IT investments and the implementation of these. A more proactive approach is followed which means a consistent use of IT. The IT systems are organisationally focussed and there is more focus on the company's need than in the previous levels. The level of IT usage therefore results in an increased understanding of the benefits.
- **Strategic**
  A company categorised as belonging to this level employs IT as part of its overall business strategy. The use of IT is a result of market pull rather than technology push. IT is used to analyse and improve the company's business processes. The structural organisation is changed so that the usage of IT is more efficient.
- **Integrated**
  The highest IT maturity level is in a company where IT plays a vital role in the organisational activities and is integrated with clients' and business partners' IT systems. More focus is on cross-organisational IT systems in order to gain competitive advantage. Changes in the organisational structure and the related work procedures are analysed and revised as a natural process in IT usage.

As the attributes are defined, any company can identify the best matching attribute and therefore only one attribute can be valid. Each of the six levels is in consecutive order indicating an increase of IT maturity in the company.

### 9.1.8 IT evaluation practice

A company's IT evaluation practice, is defined as the knowledge of, skills in and experience of, completing IT evaluations. This means, for example, that the more experience a company has in completing IT evaluations the higher is the company's IT evaluation practice. Five steps have been defined. These are described in the following.

- **Ad Hoc**
  Companies placed on this level are either not doing IT evaluations (because they do not use IT) or they may not have a standardised way of doing them. Those companies, that do IT evaluations, use primarily oral and/or subjective instructions on some IT investments (meaning not all) and are completely dependent upon individuals. They do not have guidelines for when, how and by whom, the IT evaluations should be completed.
- **Occasional**
  At this level the companies occasionally evaluate their IT investments before they are approved but, in the later stages, only when a problem occurs. Some imprecisely defined guidelines for how the IT evaluation should be done exist but the IT evaluation is highly dependent upon individuals.
- **Defined**
  If a company is placed on this level, it has written (or at least generally accepted) guidelines for how IT evaluations are done. This includes general descriptions of when to, how to and who should, do the IT evaluation. IT evaluations are always done before their approval as a one-off event but, in the later stages, only when a problem occurs. The IT evaluation process is described in general, but still depends on individuals.
- **Controlled**
  In the level called, *Controlled*, the companies have, in written form, accurately described the IT evaluation process with regard to when, how and who should, complete it. The IT investment is evaluated in at least two stages: before the approval and during on-going usage. The IT evaluation process is controlled by a third party which thereby reduces the dependence of individuals.
- **Optimised**
  The last level includes companies that have precise and written guidelines for how to do IT evaluations and thereby minimises the dependence on individuals. The IT investment is evaluated in all the major stages of its life-cycle. The IT evaluation process is continuously controlled and evaluated ensuring that necessary changes are incorporated in the written IT evaluation description.

The five attributes defined above are consecutive and therefore only one attribute can be valid.

## *9.2 IT evaluation parameters*

The second group of parameters is consisting of 7 parameters as identified in chapter 8. Each of these parameters is, in the following, defined together with a series of attributes that represent the parameter's possible "conditions".

### 9.2.1 Purpose of IT evaluation

The first parameter in this group is defined as the main reason for completing the IT evaluation. Another way of viewing the parameter is that it is focusing on the desired result of the IT evaluation. A number of purposes have been identified and are described in the following.

- **Identify the best IT investment**
  The first purpose is focused on evaluating IT investments in order to compare them and thereby identify their priority. The main purpose is to evaluate the IT investments preferably using the same method, which enables an accurate comparison used to identify the best IT investment. The IT investment with the best output should be placed first, the next best placed second, and so on. The ultimate goal of is to select the IT investment with the best output.
- **Evaluate the impact of the IT investment**
  Identifying the resources needed to implement and operate the IT investment, together with an analysis of the value achieved by using the IT system, is the essence of the second purpose. Evaluating the impact of the IT investment is important and is often used to justify the resources needed for the IT investment. Considering the fact that more and more resources are spent on IT, the company's senior managers need to justify the resource distribution.
- **Managing the IT investment**
  Managing the IT investment involves several aspects such as identifying the progress, controlling the resources spent, ensuring that benefits are achieved, implementing changes in requirements, etc. Without this type of evaluation most IT investments would have a significant risk of being considered a failure. In general it is used to establish a benchmark of the success of the actual implementation
- **Increasing the knowledge, skill and experience in IT evaluation**
  The last purpose for evaluating IT investments, is about increasing the knowledge, skill, and experience, in doing IT evaluations. An improvement is likely to occur as the company does more and more IT evaluations. Companies do not only do IT evaluations with the purpose of improving their capabilities. If companies consider this second order effect of as important, then they should establish a database, or similar data collection, to ensure that the improvements are kept.

The four IT evaluation purposes are not all considered as mutually exclusive and there might be IT evaluations where multiple purposes are being followed. It is therefore possible that several attributes can be valid at the same time.

### 9.2.2 IT evaluation criteria

A range of IT evaluation criteria are relevant when evaluating an IT investment. A criterion is, in this context, defined as a measure (either quantitative or qualitative) that shows how desirable the IT investment is with regard to a well-defined aspect that relates to the IT investment.

- **Financial**
  The financial criterion consists of two parts, the economically measurable costs and the benefits, that can both be traced back to the IT investment. Only entries that are measurable in economic terms and entries that can be converted to economic terms without assigning arbitrary values, are considered as a part of these. An example could be the IT manager's time spent on the IT investment that can be stated in economic terms. This attribute can be further differentiated into two sub-attributes:
    - Costs
    - Benefits
- **Strategic**
  The second attribute (criterion), called Strategic, is a measure of the IT investment's ability to fulfil and support the strategic plans of the company. Strategic plans include the business strategy, IT strategy, action plans and operational plans. This attribute is assigned a value

depending upon how well the IT investment supports the strategic plans. The attribute can be divided into three sub-attributes.
    - Strategic plans
    - Tactical plans
    - Operational plans
- **Competitive**
  Choosing the attribute called *Competitive*, implies that the IT investment is evaluated on the basis of the competitive advantages it provides. Competitive advantage is, in the present report, defined as all the advantages that will give the company a benefit compared to the external environment. An example could be the ability to produce products more cheaply than their rivals. The external environment for a company in the construction industry is defined in the following (the sub-attributes):
    - Customers
    - Collaboration partners
    - Suppliers
    - Rivals
    - New entrants offering the same service and/or products
    - Substitute services and/or products
- **Effectiveness of use**
  This attribute is focused on how well the IT investment increases the company's completion of existing and future business activities. The attribute is not measured in monetary terms but in increase of efficiency, effectiveness and performance. An example of this is the improvement of the company's business activities when an existing activity is done in another way. Three distinct sub-attributes of effectiveness of use are identified.
    - Efficiency of existing business activities
    - Effectiveness of changed business activities
    - Performance of new business activities
- **Quality improvements**
  IT investments, that improve the quality of services or products in any of the company's business activities, are considered as difficult to measure. Quality improvements are, in this context, defined as improving the business activities' value to the company's customers with regard to quality. Two sub-attributes are:
    - Quality improvements of services (internal and external)
    - Quality improvements of products (internal and external)
- **Requirements**
  How well does the IT investment fulfil internal and external demands? The question is the essence of this attribute. In case of, for example, outside demands, this attribute evaluates the degree of fulfilment of these demands. If, for example, the customer requires CAD drawings in a certain format then this would be addressed in this attribute. Requirements can be identified both internally and externally, however technology requirements belong to a later attribute. The sources of demands (the sub-attributes) are identified below.
    - End-user demands and needs
    - Customer demands
    - Collaboration partner demands
    - Supplier demands
- **End-user satisfaction**
  This attribute focuses on the end user satisfaction with the IT investment. It is a measure of how well the end users perceive the IT investment. An example of this is the end users' satisfaction in the implementation of an EDMS-system. The end-users' satisfaction in the IT investment is defined by the following three sub-attributes.

  - Usefulness
  - Easiness
  - Ergonomics
- **External satisfaction**
  In contrast to end-user satisfaction is external satisfaction, where customer satisfaction is most important. External satisfaction is a measure of how satisfied the company's partners are with the collaboration, services or products the company offers. Companies, from the construction industry, traditionally collaborate with, or working for, a lot of companies and this makes these relationships important. Three different external groups (sub-attributes) are listed.
  - Customers
  - Collaboration partners
  - Suppliers
  - Authorities
- **Technology**
  Technology is the focus of this attribute. The main issue is not focused on the usage (this is dealt with in the attributes called Effectiveness of use and Requirements) but on the technology itself. It is a measure on how suitable the technology behind the IT investment is. One example is the availability of projectweb solutions. This attribute can be divided into three sub-attributes.
  - Compatibility with existing environment
  - Reliability and security
  - Availability
- **Risk**
  The last attribute is about risk. Several kinds of risk are relevant to an IT investment as listed below. Risk is a measure that illustrates the likelihood of not achieving success. It is, in other words, the possibility of not fulfilling expectations. An example is the risk that the end-users' expectation is higher than is reasonable for the IT investment. Five different kinds of risk are listed below (the sub-attributes).
  - External risk
  - Organisation risk
  - Employee risk
  - Technology risk
  - Implementation risk

In total 10 parameters have been described including, for each one, a list of sub-attributes. The parameter's attributes are not mutually exclusive and therefore several might be valid in an IT evaluation.

### 9.2.3 Format of output

What format of output from the IT evaluation is desirable? The improved knowledge gained by completing an IT evaluation is dependent on the format of output. It is defined as the type of output a method provides as the final result. An example is the financial evaluation methods that typically produce a single numerical output expressing the financial value of the IT investment.

In the following list the possible attributes are described.

- **Financial**
  The first attribute is focused on financial output. It is an output that displays the IT

investment's economic value to the company and is measured in monetary terms. An example is the output from NPV that is a numerical measure using a monetary term.

- **Ratio**
  Some IT evaluation methods produce a ratio. A ratio is defined as a measure that is numerical but does not use a monetary unit. An example is IE which defines the total value as a numerical measure ranging from 0 to 150.
- **Qualitative**
  Output that is categorised as qualitative is defined as a non-numerical measure that displays the value of the IT investment to the company. Often it is displayed as a series of levels of a certain characteristic of the IT investment. An example is MBITI that uses a qualitative measure for the performance benefits with four intervals from A to D.
- **Requirement**
  The last attribute is also focused on non-numerical measures. Requirement is defined as a qualitative measure that displays the company's need/demand for the IT investment. CSF is an example of an IT evaluation method that produces an output of this type.

The type of output is also dependent upon another characteristic, that is whether the method provides a single or multiple output.

- **Single**
  Some IT evaluation methods produce a single output like NPV. A benefit of this is that conclusions on the IT investment's value may be easier to derive and if, for example, the purpose of the evaluation is to compare the IT investment with others, it is more straightforward.
- **Multiple**
  IT evaluation methods, that use several criteria, typically produce multiple output. An example is the method MBITI. A benefit of this is a more detailed representation of the IT investment's value.

Two groups of attributes have been defined in this parameter focusing on the format and the category of output. In the first group of attributes several might be relevant in an IT evaluation and should therefore be valid. The second group of attributes are considered as mutually exclusive and only one attribute can be valid.

### 9.2.4 IT evaluation champion(s)

This parameter is defined as the person or group of persons that is doing the IT evaluation and is, in this context, referred to as the IT evaluation champion. Three attributes are used as shown in *Figure 38*.

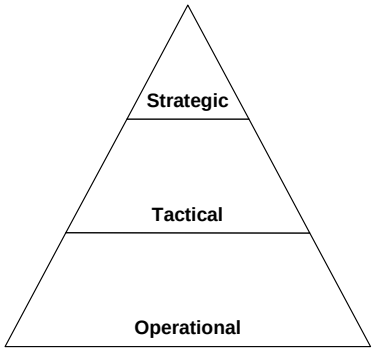



*Figure 38. A model of a company's hierarchic structure*

- **Strategic**
  The strategic level is defined as the company's top level. All employees that are working with the strategic plans of the company are considered as belonging to this level. As *Figure 38* indicates, the strategic level is generally considered as a small group compared to the rest of the company's employees. The board of directors is placed on this level.
- **Tactical**
  At the company's tactical level the main activity is converting the strategic plans into operational plans that are suitable for use at the operational level. Employees that are working with the daily management of the company are considered as belonging to this level. An example is a company's project leaders.
- **Operational**
  The bottom level works on executing the operational plans made at the tactical level. The majority of the company's employees are often placed within this level, indicated by *Figure 38*. Typical employees at this level are CAD operators, project members, secretaries, etc.

Only one attribute can be valid even though the attributes are not as mutually exclusive, since there might be cases where the IT evaluation champions represent more than one level in the company. In most IT evaluations it is, however, possible to identify the company level mostly represented by the IT evaluation champions.

### 9.2.5 User of IT evaluation

Who is using the output of the IT evaluation? The answer to this question influences the choice of IT evaluation method. The user of IT evaluation is the person or group that takes decisions and executes activities based upon the achieved output from the IT evaluation method. This could be the board of directors that either approves or rejects an IT investment proposal, or an IT manager that uses the IT evaluation output to manage the progress of the IT implementation.

The user of IT evaluation can be placed on one of three levels as shown in *Figure 38*. For the description of these group read the previous section.

The three attributes defined are not mutually exclusive (as recognised in the previous parameter) when considering the fact that several users of the IT evaluation can exist. In practice it is argued that it is possible to identify the most important group of IT evaluation users. Because of this only one attribute can be valid.

### 9.2.6 Cost of IT evaluation

The cost of completing an IT evaluation varies significantly depending on the choice of IT evaluation method. Some methods are very time-consuming whereas others are completed fast. Some can be completed by a single person, others require extensive human resources. Different attributes of costs of IT evaluations are defined in the following.

- **Inexpensive**
  Choosing this attribute implies that the cost of completing IT evaluations should be low. This means that the time required, and number of IT evaluation champions, should be.
- **Moderate**
  In this attribute some resources, meaning time and number of IT evaluation champions, are allowed but it is still limited. More advanced IT evaluation methods, than in the previous attribute, are available for use in the IT evaluation.

- **Expensive**
  If the cost of IT evaluation is allowed to be expensive then a considerable amount of resource can be spent on completing it. Most of the available IT evaluation methods can come into this category.
- **Very expensive**
  The last attribute implies that a significant amount of resource can used to complete the IT evaluation. The IT evaluation may involve a significant numbers of IT evaluation champions, and the time used on the IT evaluation is not limited with regard to this parameter. All available IT evaluation methods can be chosen.

The attributes are defined in consecutive order meaning that only one attribute should be chosen as valid. The higher the cost allowed, the more methods are available. This means that it is not relevant to choose more than one attribute.

### 9.2.7 Difficulty of IT evaluation method

The difficulty of the IT evaluation depends on which method is used. Some methods require considerable experience and expertise whereas others are easier to complete. The difficulty of an IT evaluation method is defined as the complexity of the method with respect to data and expertise requirements.

Four different categories of difficulty of the IT evaluation method are defined.

- **Low**
  IT evaluation methods in this category generally have the lowest requirements for experience and expertise of all the available methods. Companies, that have no, or very little, experience in completing IT evaluations will be able to use the methods in this category. Companies which do not want to use a method that requires some experience and expertise, will choose this category.
- **Moderate**
  In this category are IT evaluation methods that require a moderate level of experience and expertise. Companies that have some experience and expertise will be able to use methods in this category. Companies that want to use a method that requires some experience and expertise will choose this category.
- **High**
  In this category the methods require considerable experience and expertise in completing IT evaluations. Those companies which choose this category, either have experience of, and expertise in, making IT evaluations, or they want an IT evaluation method that is more complex and thus requires more experience and expertise. The number of available IT evaluation methods is high in this category.
- **Very high**
  The last level includes all the available methods and some of them may require extensive experience and expertise in completing IT evaluations. Only companies that fulfil these requirements, or consultants with expertise in IT evaluation, should choose this attribute.

This attribute should be chosen on the basis of a company’s experience and expertise in IT evaluation, and on the basis of the desired level of complexity of the IT evaluation method. Only one attribute can be valid as they are defined in consecutive order.

## 9.3 IT investment parameters

The last group consists of six parameters where each is defined and a series of attributes are described.

### 9.3.1 Type of IT investment

The type of IT investment is defined as the main usage of the IT investment. This means that the type of IT investment is not directly related to the nature of the technology, but rather on the usage of the technology. An advantage of this is that each attribute defined includes a wider selection of IT technologies than if the type of technology was used to define the attributes.

Eight different types of IT investment have been defined by a framework developed by (Farbey, Land, & Targett 1993). *Figure 39* shows the different types of IT investments together with an overall structure.


*Figure 39. The ladder framework (Farbey, Land, & Targett 1993)*

Each rung represents a type of IT investment and, in general, the higher the rung the greater impact the IT investment has on the company (this is not always the case). The rungs are generally described by the way IT changes or improves the company and its business activities. Another characteristic of the rungs is the higher rung implies, in general, a higher uncertainty in the impact.

1. **Mandatory changes**
   The lowest complexity of IT investment is categorised as mandatory or forced changes. Three types of forced changes affect IT system decisions: (a) if the company is under competitive pressure it may be necessary to imitate a competitor, (b) if the company is forced to make certain technological changes it may be a technological necessity to adopt IT investments, (c) changes in IT systems can be predetermined by regulation and legislation. An example of this is the Automatic Teller Machine (ATM) in banks.
2. **Automation**
   This rung represents IT investments designed to replace existing business operations in order to reduce costs. Reducing the cost of business activities may be an important strategic objective and can provide competitive advantage. IT investments on this rung can increase the labour productivity dramatically, especially white-collar labour, with an increased company capacity as consequence. A classical example is payroll systems.
3. **Direct value added**
   The third rung is representing IT investments which not only reduce costs but also add value by doing operations not done before. They are intended to improve some aspects of business performance that had already been identified as “valued”. The added value does, however,

not necessarily accrue to the company. This is most common in highly competitive situations or where regulations or patents do not protect the IT investments. Home banking systems provided by the banks are an example of this.

4. **MIS and DSS systems**
   This represents IT investments that provide information for planning, control and decision-making. Providing better quality information enables managers to make better decisions. Better means, in this case, more accurate, timely, relevant, reliable information and information presented in a more easily used form. The value added by these IT investments is only accrued if the ones using them have the skills and opportunity to take advantage. "Intelligent" expert advisory systems used to create bills of quantities are an example of this.
5. **Infrastructure**
   This rung represents IT investments which provide a general capability but may not be targeted at any specific IT system. They provide a basis upon which other IT systems can be used to add value to the company. This type of IT systems is predicted to be a more widely invested area in the future. An example of this is the implementation of Local Area Networks (LAN).
6. **Inter-organisational systems**
   Rung 6 represents IT investments with links across companies' boundaries which means two or more companies sharing the IT system. The value added by the IT investments may, however, not necessary accrue equally to the collaborating companies. The IT investments require a closer collaboration and increased trust between the companies and may mean a loss of flexibility. A widely used example on an IT investment belonging to this attribute is Electronic Data Interchange (EDI).
7. **Strategic systems**
   This type is classified by a strategic use of IT systems. Michael J. Earl has defined strategic use of IT as follows (Earl 1989):
   1. Gaining competitive advantage.
   2. Improving productivity and performance.
   3. Enabling new ways of managing and organizing.
   4. Developing new types of business.

   In order to use IT strategically the IT strategy must be aligned closely to the business strategy and has to be at least supported by the senior management in the company. The risks are considered as high in this type of IT system. Dillingham Construction, a US contractor, is an example of how strategic use of IT could be done (Betts 1999).
8. **Business transformations**
   The top rung on the ladder is IT investments that enable a company to transform its business. This is of a highly strategic character. It can be initiated by a company desiring to change its business or if it is forced to change the business because of economic difficulties. This rung is usually not enabled by IT systems alone but also by change in management of human resources, organisational changes etc.

Each of the 8 rungs has its own characteristics but examples from industry can rarely be categorised satisfactorily by one single rung. It could be argued that mandatory IT investments can belong to any of the seven other rungs because the characteristics of this rung are not applied to the technology behind the IT investments, but to the conditions that lead to the IT investment. It is, however, argued that it is possible to identify the rung that characterises the IT investment mostly and therefore only one attribute can be valid. In general the higher on the ladder the IT investment is categorised, the more involvement from senior management is required and the more complex and uncertain is the IT evaluation.

### 9.3.2 Size of IT investment

The second parameter in this group is called, *Size of IT investment*. It is defined as the level of resources needed to be spent on the IT investment. It is, in this context, important to stress that the parameter is not referring to a detailed specification of the needed resources but rather an indication of whether the IT investment is large or small.

The size of the IT investment is defined by using four attributes which are defined in more detail by the level of resource required for the IT investment.

- **Small**
  This attribute refers to IT investments that are considered as requiring a small level of resource, but which still need to be evaluated by using formal IT evaluation procedures.
- **Medium**
  IT investments that require a moderate level of resources from the company, are categorised in this attribute. They may not always require a detailed IT evaluation.
- **Large**
  This attribute refers to IT investments that require a high level of resource. The need for a detailed IT evaluation is therefore significant.
- **Very large**
  The last attribute contains all IT investments that require a very a high level of resource from the company. The need for a detailed IT evaluation is very important.

The four attributes are defined so that they are relative, meaning that they can be related to the characteristics of the company. For example, what a small company considers as a very large IT investment might, in a large company, not be considered as large.

The attributes have been defined so that all sizes of IT investment can be assigned one attribute and therefore only one attribute can be valid.

### 9.3.3 Purpose with IT investment

The parameter, *Purpose of IT investment*, is defined as the desired main impact of implementation using the desired IT investment. The main impact of the IT investment refers to the general type of benefit achieved.

Three different attributes are defined in order to describe the main purposes available. The attributes have been inspired by the work of (Farbey, Land, & Targett 1995a), which also has been described in chapter 2.

- **Automate**
  The first attribute is relevant for IT investments in which the main purpose is to replace existing working procedures with IT-based working procedures. A well-known example is the payroll system that replaced rather extensive and time-consuming office work. IT investments for this purpose do not increase the value of the business activities but reduce the cost of performing them. This effect does not often result in a reduction of the labour force but in increased capacity.
- **Informate**
  The second attribute is focused on IT investments that increase the availability of data and information and thereby enhance the value of the affected business. They are used to facilitate a more effective management and control of the company's business activities.

These IT investments either change the working procedures, or the way they are completed, but the output is still the same.

- **Transformate**
  In IT investments, where the purpose is to transform the business activities, the main reason is to change the output of the business activities. Changing output also means a change in working procedures. IT investments of this kind transform the company's business activities so that it has better opportunities in competition.

Often IT investments have more than one purpose, but it is nevertheless argued that one purpose can be identified as more important than others, and therefore only one attribute can be valid.

One important aspect needs to be mentioned in this context. IT investments based on similar technology might not necessarily have the same purpose even though the same potential exists. The purpose of the IT investments is dependent on the technology used, but also on how the technology is used. It is therefore possible even though the same technology is used, that the purposes are different.

### 9.3.4 IT investment's domain

All IT investments can be related to a domain and this will influence the choice of IT evaluation method. The IT investment's domain is defined by organisational boundaries like company, building projects, etc. An IT investment can be characterised as having a value within some organisational boundaries. Choosing the IT investment's domain does not necessarily mean that its value is limited to the organisational boundary, but rather that the IT evaluation only include the value achieved in that domain. Many IT evaluations are focused on the company level, but other levels could also be chosen. One example is evaluating a project web system, which can either be limited to a company or to a group of companies collaborating in a building project. The IT evaluation is most likely, in these organisational domains, to result in different output.

A range of attributes is defined in the following.

- **Person**
  The first level of organisational domain is limited to a person. Evaluating an IT investment in this domain indicates that the focus is on evaluating the impact on a selected individual. Such an IT evaluation would typically need a very detailed information level by, for example, analysing the change in working procedures for the selected individual.
- **Department**
  In the second level the scope of the IT evaluation is within the department of an organisation. The IT evaluation focus, in this case, is on evaluating the IT investment within a selected department. This involves several persons that are related to a specific business activity, and the evaluation may therefore focus on the changes to the business activity rather than a number of individuals.
- **Company**
  Choosing the company domain implies that the IT evaluation is focused on the value of the IT investment to several departments or business activities that span across several departments. The IT investment is evaluated on the basis of the value to all the company's business activities.
- **Building project**
  Evaluating an IT investment on a building project level is either focused on the value of the IT investment in one company, that is involved in a building project, or on the group of companies that are collaborating in the building project. The first possibility implies that the

IT evaluation is limited to the value from one building project on one company, whereas the other possibility evaluates the value on one building project but for several companies. The latter implies a more complex evaluation as the IT investment's value, as perceived by several companies, has to be included.

This parameter's attributes are described consecutively and it is therefore not possible to complete an IT evaluation using multiple domains as this would imply conflicts when, for example, the level of detail is determined. As the attributes are defined, they increasingly include a wider organisational scope when a "higher" attribute is chosen. There can therefore only be one valid attribute.

### 9.3.5 Stage of IT evaluation

This parameter describes the different stages of an IT investment's lifecycle where an evaluation is completed. It is defined as the stage at which the IT investment's status is radically changed. The stages defined are in chronological order.

The six different stages are displayed in *Figure 40*.

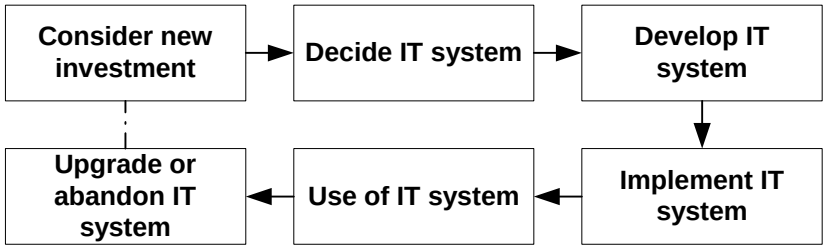



*Figure 40. IT investment's life-cycle*

Each of the stages is described in the following

- **Consider new IT investment**
  This stage is the earliest of the six and perhaps also the most difficult to describe. Often major strategic considerations are made at this stage focusing on which types of IT investment the company should implement. The IT investments are, at this stage, not defined very precisely and the requirements need to be identified. Completing this stage implies that the company has identified the type of IT investment and the requirements.
- **Decide IT system**
  The second stage is focusing on selecting the IT system to be implemented. Typically, this stage will be completed by surveying the available IT systems in the market that fulfil the requirements defined by the company, in the first stage. The IT investment will, during this stage, be more precisely defined and will end up with the selection of the best IT system available, or the company will decide to develop their own IT system.
- **Develop IT system**
  If none of the available IT systems on the market fulfil the necessary requirements, the company can decide to develop their own IT system and this is typically done at this stage. If the company identifies a suitable IT system, they might want to amend it so that it supports the company's special requirements. This would be completed in this stage.
- **Implement IT system**
  Once the IT system plus additional amendments has been developed, it should be tested (if not completed in the previous stage) and implemented in the company. The testing could be

done by a group of super-users and/or pilot projects. Another important activity, after the technical implementation, is the education of the end users. The stage is completed when the IT system is ready for use in the company.

- **Use of IT system**
  This stage is considered as important because the benefits of using the IT system should be achieved here. The daily operation of the IT system is the main activity at this stage, together with support for the end-users' needs. This stage is completed when a major upgrade is considered as necessary, or if the IT system needs to be replaced or abandoned.
- **Upgrade or abandon IT system**
  The last stage is focused on either deciding to upgrade the IT system, replacing it with another, or abandoning it. The stage is completed when the company has decided which of the three actions to initiate.

Because the stages defined are listed in chronological order it is not possible that more than one attribute can be valid.

The first three stages can be characterised as ex-ante IT evaluation, and the last three as ex-post. Ex-ante evaluations are predictive in nature and require estimates (either hard or soft) of not realised costs and benefits. The last group, called ex-post, is primarily focused on measuring the realised impact of the IT investment.

### 9.3.6 Importance of IT investment

The last parameter in this group is focused on the IT investment's importance to the company. This is relevant because of the higher importance of the higher need for an IT evaluation.

There is no absolute measure for the importance of an IT investment and therefore the following attributes are defined.

- **Low**
  In cases where the IT investment is considered as not important to the company, this attribute should be chosen. A low importance indicates that it is not considered as necessary or as a prerequisite to other IT investments. Not implementing an IT investment in this category only has a small impact on the company.
- **Moderate**
  IT investments, with a moderate importance to the company, influence the company to a minor degree and are seldom a prerequisite to other IT investments. These are considered as relevant but they also indicate that they have a small to moderate impact.
- **High**
  This attribute contains all IT investments that are considered, by the company, as important either because they are prerequisite to other IT investments, or because they are central to the company's strategic plans. The IT investment's impact is, in most cases, considerable.
- **Very high**
  The last attribute is about IT investments that are regarded as having a very high importance. The importance indicates that they are a necessary prerequisite to other IT investments or that they fulfil a central part of the company's strategic plans. The impact on the company is considered as very significant.

The four attributes defined are consecutive, which means that only one of the attributes can be valid. The choice of IT evaluation method is dependent on the importance of the IT investment because, firstly, the higher the importance the higher is the need for completing a detailed IT

evaluation and, secondly, the higher the importance the higher the cost of completing the IT evaluation.

## 9.4 The parameters' overlap

The last part of this chapter is describing the potential of the parameters' attributes. The parameters attributes' are, in some cases, in conflict with each other, which requires that a relationship is defined and describes the actions needed to resolve the conflicting attributes.

Firstly, the three groups of parameters are described with regard to the potential overlap between the attributes. Secondly, the potential overlaps across the three groups of parameters are described.

### 9.4.1 Overlap in *Company*

The following paragraphs contain descriptions of the potential overlap between the group of parameters' called, *Company*, and their attributes.

One potential overlap has been identified as influencing the attributes' consistency.

**Role of IT *and* IT maturity**

The parameter, *Role of IT*, is related to the parameter, *IT maturity*. This relationship is implying that a high current impact and dependence on IT on the company also means that the company's IT maturity is high. It is, because of this, considered as impossible that a low impact and dependency on IT (which is the case in the attributes: *Support* and *Turnaround*) can be valid if the IT maturity is high (more precisely the attributes: *Strategic* and *Integrated*).

In the case of an inconsistency in the parameters' attributes this has to be changed so that the attributes have an appropriate relationship.

### 9.4.2 Overlap in *IT evaluation*

Among the parameters defined as belonging to the group of parameters called, *IT evaluation*, one potential overlap has been identified. This is described in the following.

***IT evaluation champions* and *User of IT evaluation***

The potentially overlapping parameters are, *IT evaluation champion(s)* and *User of IT evaluation*. The parameters' relationship is restricted for some of the attributes as it is not considered possible that the IT evaluation champion(s) is/are from the strategic level, when the *User of IT evaluation* is from the operational level. This is because it is not realistic to believe that the strategic level will complete an IT evaluation in which the operational level will use the output. All the other combinations are considered as realistic.

### 9.4.3 Overlap in *IT investment*

In the third group of parameters there are also potential overlaps between some of the attributes.

The three potential overlaps are identified and described in the following.

***Type of IT investment* and *Size of IT investment***

There is a potential overlap between the two parameters, *Type of IT investment* and *Size of IT investment*, in one case.

Considering that the IT investment is categorised as the type: *Business transformation*, it is not possible for the size of the IT investment to be small, because the resource needed to complete a business transformation cannot be small, as such a change involves many changes in the company's business activities.

***Type of IT investment* and *Purpose of IT investment***

The parameter, *Type of IT investment*, is related to the parameter, *Purpose of IT investment*, basically because of the way they are defined. In some cases there is an overlap between the usage of the IT investment and the primary impact achieved. This is valid when the usage of the IT investments is categorised as *Automation,* which also implies that the main impact is categorised as *Automate*.

Especially the three attributes: *Automation*, *MIS and DSS systems* and *Business transformations* are strongly related to the respective attributes defined in the parameter, *Purpose of IT investment* (more precisely: *Automate*, *Informate* and *Transformate*). It is thereby inconsistent, if these three types of IT investment are not related to the corresponding attribute in, *Purpose of IT investment*. This cannot therefore be allowed. The reverse relationship cannot, however, be claimed as valid. The other attributes in the two parameters are not limited by a relationship.

***Type of IT investment* and *IT investment's domain***

Certain types of IT investment are considered as having an impact on a minimum level of organisational domain like, for example, the attribute: *Strategic systems*, which at least has an impact on the organisational domain called *Department*.

The following types of IT investment, *Inter-organisational*, *Strategic systems* and *Business transformations*, are therefore argued as having an impact on at least the organisational domain, *Department*, which means that the IT investment's domain called, *Person*, cannot be valid for these types of IT investments.

### 9.4.4 Overlap between the three groups of parameters

The following sections describe the relationship between the different groups of parameters' attributes.

***Purpose of IT evaluation* and *Stage of IT investment***

Two potentially overlapping parameters are, *Purpose of IT evaluation* and *Stage of IT investment*. Certain IT evaluation purposes would not be used in all stages of the IT investment's lifecycle and therefore the consistency of the attributes has to be ensured. The potential overlaps, described in the following, are based on the assumption that there is a logical sequence for the IT investment's life-cycle, and that the related IT evaluations completed in each of the stages support the logical sequence of stages.

*Figure 41* shows which of the purposes are relevant at which stage of the IT investment life-cycle.

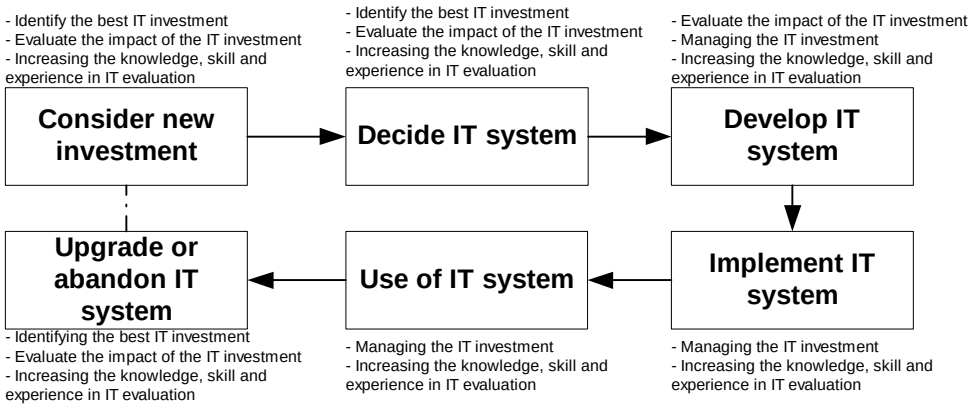



*Figure 41. IT evaluation's purpose contra IT investment's life-cycle*

*Figure 41* can be used to identify the inconsistencies in the attributes of the two parameters. In these cases the chosen attributes need to be reconsidered so that consistency is established.

### *Cost of IT evaluation* and *Type of IT investment*

Another set of potentially overlapping parameters is, *Cost of IT evaluation* and *Type of IT investment*. In general the higher the rung of the IT investment (see the definitions of these earlier in this chapter), the higher the complexity and the higher the cost of the IT.

An example illustrating this inconsistency is when a low rung IT investment needs to be evaluated, and this allows a very high cost of IT evaluation method. This situation is not logical in most cases and will therefore have to be reconsidered so that the inconsistency is corrected.

Another extreme example is when a high rung IT investment is evaluated with a method where the cost of the IT evaluation is low but, in this case, it should be valid because it is desired that the cost of IT evaluation is as low as possible.

### *Cost of IT evaluation* and *Size of IT investment*

Between the parameters, *Cost of IT evaluation* and *Size of IT investment*, there are a few potential overlaps which are described in the following.

In the case where the size of the IT investment is large or very large, it is not regarded as sensible if the cost of the IT evaluation can only be inexpensive. This overlap is valid but would lead to an unbalanced IT evaluation, where the chosen method cannot provide the IT evaluation champion(s) with a proper level of detail of the IT investment. This potential overlap is therefore not regarded as allowable.

The reverse situation is not considered as sensible either. In this case the overlap is that the size of the IT investment is characterised as small, whereas the cost of IT evaluation allowed is very high.

### *Cost of IT evaluation* and *Importance of IT investment*

The last potentially overlapping parameters are, *Cost of IT evaluation* and *Importance of IT investment*. The relationship between these parameters is proportional. The more important the IT investment is considered the more resources are likely to be spent on the IT investment. Even though the IT investment is considered as very important by the company, it might decide to use an

inexpensive IT evaluation, which implies that the two parameters' attributes can be chosen independently, except in one case.

In the case where the IT investment has a low importance, it is unlikely that the cost of the IT evaluation is allowed to be very high, because no company would approve such spending on IT evaluations.

## 9.5 Summary

In this chapter 21 parameters have been defined and a series of attributes, which represent different alternatives in each parameter, have been described.

The parameters, and the related attributes, can be used in the framework to characterise different IT evaluations, enabling the user to more precisely identify the requirements for the IT evaluation method. The parameters attributes' influence on the choice of method, are in focus in the next chapter.

The overlaps between the parameters' attributes have been described in order to ensure that the choice of attributes is consistent.

# Chapter 10: Relationship between the attributes and the methods

This chapter describes the relationship between the parameters, as described in chapter 9, and the four IT evaluation methods (see chapter 3), which have been tested in the five case studies.

The approach used in this chapter is that each parameter is described with regard to their relationships with the four methods. The relationship between the parameters and the four methods can be used to select the best matching method in an IT evaluation. This is used in chapter 11 in the development of the framework.

In the last part of the chapter the tables (that are describing the relationship between the parameters' attributes and the four methods) are combined into three tables, each representing one of the three groups of parameters as identified in chapter 8. The three tables give an overview of each group of parameters' influence on the choice of method.

## *10.1 The relationship between the parameters' attributes and the four methods*

The relationship between the parameters' attributes and the four IT evaluation methods in each of the three groups of parameters, is shown in a series of tables throughout this chapter. This is described in the tables by using three levels which are, **X**, **(X)** and **No Cross** to describe the usability of the method. These are defined in order to express the degree of usefulness of the IT evaluation methods to each attribute.

**X**
The usability score, **X**, is defines that the IT evaluation method is **useful** in fulfilling the requirements of the parameter's attribute. A method given this usability score in an attribute, is both capable and efficient in fulfilling the derived requirement.

**(X)**
This usability score is defines that the IT evaluation method is **usable** to fulfil the requirement from the respective attribute. It indicates that the method can be used to fulfil the requirement but is not efficient in doing so.

**No Cross**
The definition of the last usability score is that the IT evaluation method is **not useful** when fulfilling the requirement. The method given this usability score is not capable of fulfilling the derived requirement. This is shown in the tables as a blank cell.

### 10.1.1 Assigning the usability scores

For each of the parameters' attributes a usability score, as defined above, is assigned to each of the four methods depending on its usefulness in fulfilling the identified requirement.

The methods' usability score is assigned to the attribute: (a) by analysing the attribute's derived characteristics, (b) by analysing the four methods' characteristics (hereunder the identified strengths and weaknesses) and (c) by analysing the findings from the case studies (where possible).

## 10.2 The relationship between the attributes and the methods in Company

The relationship between the parameters' attribute(s) and the four IT evaluation methods in the group of parameters called *Company*, is described in the following.

### 10.2.1 Company type

Both architects' and consulting engineers' main business activities are, to some extent, based on creativity and knowledge. Most IT investments in these companies are difficult to evaluate with quantitative measures because of the large degree of qualitative aspects in their IT usage. The building material suppliers and contractors can, with advantage, use more quantitative methods than the other two types of company, because their main business activities can be characterised as production-oriented, which are more easily evaluated using quantitative measures.

*Table 23. Relationship between Company type and the four IT evaluation methods*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **Type of Company** | | | | |
| Building material supplier | X | X | X | (X) |
| Architect | | X | X | X |
| Consulting engineer | | X | X | X |
| Contractor | (X) | X | X | X |

As seen in *Table 23* the type of company does not significantly limit the choice of IT evaluation method. Generally the reason is that the four methods are considered as usable in almost all the different types of companies.

The case studies involved two types of company: consulting engineers and contractors. Completing the case studies with these types of company confirmed the table above by revealing that NPV was more suitable for the contractors than for the consulting engineers, mainly because the contractors' activities are more quantifiable due to production-oriented work rather than knowledge-based work. This was especially found in the case study with the small contractor.

### 10.2.2 Company size

In general the company size does not significantly limit the number of available methods, because the methods can be applied no matter what company size. One aspect needs, however, to be considered when mapping this parameter's attributes to the methods.

Small companies tend to be focused on more practically oriented problems than large companies because the complexity of the IT investments is smaller, whereas large companies' need to plan the IT investments is more demanding because of higher complexity. A small company will therefore benefit more from methods that are simple and practically oriented and which do not use too many theoretical concepts (that solve the more complex issues in IT evaluations). The larger companies, however, often need more complex IT evaluation methods because of more complex needs.

*Table 24. Relationship between Company size and the four IT evaluation methods*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **Company Size** | | | | |
| Small (1-20) | X | X | | X |
| Medium(20-100) | (X) | X | X | X |
| Large (100+) | (X) | X | X | X |

The five case studies represent two of the defined attributes: small and large. Four of the companies are categorised as large and one as small. In the group of large companies the method, NPV, was found to have too narrow a focus and could not reflect the value of the IT investments to the companies. The three other methods gave a better representation of the IT investment's value. The case study with TJAS, however, revealed that the IT evaluation champions found the complex methods (primarily IE) too theoretical and that NPV was better.

### 10.2.3 Company position

*Table 25* shows the relationship between the parameter, *Company position*, and the four IT evaluation methods.

*Table 25. Relationship between Company position and the four IT evaluation methods*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **Company position** | | | | |
| Lagger | (X) | | | X |
| Follower | | X | X | X |
| Leader | | (X) | X | (X) |

IE is the method that has the highest focus on the competitive value of the IT investment which therefore makes it the best method for the following attributes; Leader and Follower. For the attribute Lagger, "only" CSF and, partly, NPV are relevant because they focus on respectively the success criteria and the financial value of the IT investment, which are areas of more importance for companies in this position.

The case studies showed this clearly, as Cowi (categorised as Leader) wasrated the competitive value as important in their IT evaluation, whereas NIRAS (categorised as Follower) did not put the same emphasis on the competitive value. The same tendency was experienced in the case studies with the two contractors.

### 10.2.4 Business strategy

The choice of generic business strategy will, in most cases, have a minor influence on the choice of IT evaluation method because the relationship between these is not straightforward. In abstract terms pursuing one of the four generic strategies would influence the desirability of the type of IT investment and this will indirectly affect the choice of IT evaluation method.

*Table 26. Relationship between Business strategy and the four IT evaluation methods*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **Business Strategy** | | | | |
| Cost leadership | X | X | X | (X) |
| Differentiation | | (X) | X | X |
| Cost focus | X | X | X | (X) |
| Differentiation focus | | (X) | X | X |

Two main trends are seen in *Table 26*. First, companies pursuing a cost-oriented strategy are more interested in evaluating the financial savings of the IT investments, whereas companies pursuing a differentiation-oriented strategy are interested in evaluating the potential value of new services/products. IE is the only method capable of supporting both of the generic strategies because of its focus on the financial value, strategic value and competitive value.

A more detailed description is given in the following.

- **Cost Leadership**
  Companies pursuing this generic strategy would primarily use IT to reduce the cost of their business activities. IT would not be considered as an enabler of new business areas but more as increasing the efficiency and effectiveness of its existing business activities. Desirable IT investments aim at reducing the cost of the business activities. Based on these characteristics the choice of IT evaluation method should be based on those that seek to evaluate the cost savings achieved by using the IT investment.

  Four of the case study companies (Rambøll, Cowi, NIRAS and H&S) pursue this strategy (they also happen to be the four large companies). A common criterion in the IT evaluation for these companies was found to be the IT investments' value in economic terms, but other criteria were used as well. Especially Rambøll was interested in both quantitative and qualitative benefits of the IT investment.

- **Differentiation**
  Those companies pursuing differentiation as a generic strategy will primarily aim to differentiate themselves by using IT to provide unique services or products no one else can offer. IT investments, that are desirable to the company, will therefore primarily aim at providing different services or products. IT evaluation methods that evaluate the IT investment's contribution to creating new business areas, services and/or products, are therefore considered as relevant.

  None of the case study companies is categorised as pursuing this strategy.

- **Cost Focus**
  Companies pursuing the strategy called, *Cost focus*, will, like the companies who are aiming at *Cost leadership*, focus on using IT for reducing the cost of the business activities. The role of IT will therefore, within the services or products offered to the small customer segment, aim at increasing the efficiency and effectiveness of the business activities. Desirable IT investments, that support the business strategy, will primarily aim at reducing the cost of operation. Again the choice of IT evaluation method should be from those that seek to evaluate the savings of the IT investment.

One case study company (TJAS) was categorised as pursuing this strategy (the small contractor). As was the case with the other four companies, the main criterion was the IT investment's financial value.

- **Differentiation Focus**
  The last generic strategy implies that companies will use IT to differentiate themselves within the narrow customer segment targeted by the company. The role of IT will therefore focus on supporting and creating different products and services than other companies, for example, by creating new business areas. Desirable IT investments will aim at using different services or products than are provided by other companies. IT evaluation methods that evaluate the IT investment's value for differentiating the company with regards to services or products offered to the small market sector targeted, are considered as valuable.

  None of the case study companies are categorised as pursuing this strategy.

### 10.2.5 Decision Environment

It is very difficult to derive information on how the relationship between a company's decision environment and the four methods can be described. One aspect is, however, certain; the content of the company's standards and procedures for how to produce and present the information is relevant when considering which method to use.

*Table 27. Relationship between Decision environment and the four IT evaluation methods*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **Decision Environment** | | | | |
| No standards and procedures | X | X | X | X |
| General guidelines, that can be expanded if needed | X | (X) | X | (X) |
| Written standards and procedures | X | (X) | X | (X) |

Depending on how the company's decision environment can be characterised, it will influence the choice of IT evaluation method as described below.

- **No standards and procedures**
  Companies that, for some reason, have no standards or procedures for how to produce the information needed when making IT related decisions, are not limited to a few of the available methods and should therefore base their choice on other parameters. This attribute cannot therefore be used to determine which IT evaluation method to choose, and therefore all methods should be usable.

  None of the case study companies' decision environments can be categorised as belonging to this attribute.

- **General guidelines that can be expanded/amended**
  In a decision environment, where there are some general guidelines for how to make decisions, but where they can, if needed, be expanded or amended, the choice of IT evaluation method might be limited. The choice of method should therefore be among those that are flexible but also where the output provided are standardised. NPV and IE are the only methods fulfilling these requirements satisfactorily (the flexibility of NPV is however only related to the detail level of the financial analysis).

All five case study companies have a decision environment categorised by this attribute. They all have some general procedures for how to make decisions regarding IT. In H&S all major IT investments are analysed by the IT department and on the basis of this they write a recommendation to the board of directors (see Appendix E4), who then make the final decision.

- **Written standards and procedures that have to be followed**
  If the company has defined (and written) standards and procedures for how to produce the information on which decisions are taken, then the IT evaluation method chosen will have to support these. An example could be a company where all major investments need to fulfil certain economic criteria, for example, using discounted cash-flow technique. If the company sustains these demands as valid for IT investments, then the choice of IT evaluation method has to fulfil these. Both NPV and IE are useful because they provide highly standardised output, whereas MBITI and CSF are less standardised.

  None of the case study companies have a decision environment that can be categorised by this attribute.

### 10.2.6 Role of IT

Two trends are relevant when considering the relationship between this parameter and the methods. First, for companies where the dependence and impact of IT is low today, the need for methods that evaluate the current impact is small. In companies, where the role of IT will be low in the future, the need for evaluating the potential of IT investments is small. Second, in companies where IT today implies a high dependency and impact from IT, the need for evaluating the current impact is high and, likewise, if the role of IT is high in future, the potential needs to be evaluated.

*Table 28. Relationship between Role of IT and the four IT evaluation methods*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **Role of IT** | | | | |
| Support | X | (X) | | X |
| Turnaround | | X | X | |
| Factory | X | (X) | (X) | X |
| Strategic | X | X | X | X |

How the characteristics of the company's role for IT are defined will influence the choice of IT evaluation method. The influences are described in more detail in the following:

- **Support**
  If the company defines the characteristics as low dependence and impact of IT now and in the future, it implies that the company does not have special requirements for an IT evaluation method. The existing IT systems do not have a significant role in the company and therefore the need for measuring the achieved value is less than for companies with a high current impact. Likewise companies placed in this square do not consider IT as an important contribution in the future, and it is therefore not very important to evaluate future IT investments. In general it is not possible for this attribute to be used to make a choice among the IT evaluation methods. The more complex methods are regarded, however, as less good because of their large resource needs.

One of the case study companies (NIRAS) is categorised thus. Their usage of IT is mostly regarded as a support to their core business activities. This also implies that the company does not spend many resources on keeping in pace with the technology development as is the case in some of the other case study companies.

- **Turnaround**
  Future IT investments are considered to play a significant role by companies placed in this square, whereas the current uses are considered as less important. These characteristics imply that: (a) evaluating current benefits is less important, and (b) the strategic aspects of future IT investments are important. The choice of IT evaluation method will therefore have to focus on the strategic aspects of the future IT investments rather than evaluating the impact of the existing IT systems.

  Four out of five of the case study companies are categorised in this group because they all expect their future IT usage to be a major factor in their business activities, whereas they are only partially dependent on their IT usage today. Their ability to evaluate IT investments was found to be important to the case study companies.

- **Factory**
  Companies placed in this square have a high dependence and impact of IT today, but consider the future usage of IT as less important. The main focus is therefore on evaluating the current use of IT rather than focusing on future IT investments. In general this implies a need for methods that evaluate the current IT investments with regard to identifying their value.

  None of the case study companies are categorised as belonging to this group.

- **Strategic**
  The last square contains companies in which the current and future usage of IT systems are considered as having a significant impact. The need for IT evaluation methods is therefore complex because, both the impact of the existing IT systems and future IT investments, need to be evaluated. This requires more advanced IT evaluation methods and may even imply that the company has to use more than one method.

  None of the case study companies are placed in this group.

### 10.2.7 IT maturity

The relationship between this parameter and the methods is relatively simple and is based on two rules. First, the more mature the company's IT usage is, the more complex an IT evaluation method can be used. Second, if the methods' complexity is ranging from low to high, the methods are respectively ranked: CSF, NPV, MBITI and IE.

*Table 29. Relationship between IT maturity in company and the four IT evaluation methods*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **IT Maturity in Company** | | | | |
| Not applicable | (X) | | | (X) |
| Occasional | X | (X) | | X |
| Responsive | X | X | (X) | X |
| Planned | X | X | X | X |
| Strategic | X | X | X | X |
| Integrated | X | X | X | X |

None of the case study companies have a very high IT maturity because they have no integration of either the clients' or the business partners' IT systems. Three of the case study companies (Rambøll, Cowi and H&S) have an IT maturity characterised as *Planned* whereas the last two (NIRAS and TJAS) are characterised as *Responsive*. The common experience in the case studies was that the higher the IT maturity in the company, the more relevant were the more complex methods.

The company's level of IT maturity will influence the choice of IT evaluation method in the following way.

- **Not applicable**
  Since companies with this maturity level are, by definition, not using IT as a support in their business activities, no IT evaluation method should be used. If the company plans to implement a new IT system then it should contact an external consultant who should evaluate the IT investment for the company.
- **Occasional**
  On this level the company's experience of using IT is very low, meaning that the knowledge and experience of using IT, and the achieved effects, are small. The choice of IT evaluation method should therefore aim at a simple method that requires little knowledge and experience to complete.
- **Responsive**
  Companies at this level have some knowledge and experience of using IT, but new IT investments are mainly implemented for legislative or competitive reasons. The choice of IT evaluation method should therefore focus on methods that are simple and usable for evaluating these criteria.
- **Planned**
  On this maturity level the companies' usage of IT is planned according to defined strategies. Some knowledge of the IT investments and the desired benefits are in place, and the choice of IT evaluation method can therefore, with advantage, use this knowledge. The method used can be advanced if necessary.
- **Strategic**
  On this level the IT maturity is high which implies an advanced usage of IT in fulfilling some of the objectives stated in the business strategy. Since IT investments in general are implemented as part of a strategic plan, the choice of IT evaluation method should evaluate the strategic dimension. The method can be advanced if needed.
- **Integrated**
  In companies where IT is used to integrate the company with its customers and suppliers, this implies a quite advanced use of IT. The company has a considerable amount of knowledge and experience in using IT, both strategically and to establish links to other

companies in the value chain. The choice of IT evaluation will, in most cases, have to be a advanced method that is capable of evaluating cross-organisational IT investments.

### 10.2.8 IT evaluation practice

*Table 30* shows an almost similar relationship between the parameter and the methods presented in *Table 29*. This is because the higher knowledge, skill and experience in the company's IT evaluation practice implies a higher capability for using more complex methods. CSF can, however, be used without regard to the company's IT evaluation practice.

*Table 30. Relationship between IT evaluation practice and the four IT evaluation methods*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **IT Evaluation Practice** | | | | |
| Ad hoc | (X) | | | X |
| Occasional | X | (X) | | X |
| Defined | X | X | (X) | X |
| Controlled | X | X | X | X |
| Optimised | X | X | X | X |

None of the case study companies have a high level of IT evaluation practice. The company with the highest is Cowi, which was characterised as *Defined* because they have established and described some standards for how to evaluate their IT investment. They have initiated a project where the main objective was to evaluate the economic benefits of three key IT investments (SAP, Outlook/Exchange and DWS). The other case study companies' IT evaluation practices were either categorised as Ad Hoc or Occasional. The main experience from the case studies was that the companies did not have much experience in completing IT evaluations, and using any of the four methods was a step forward for them.

Each level's influences on the choice of IT evaluation method are described below.

- **Ad Hoc**
  Companies with an ad hoc IT evaluation practice either do not need to choose an IT evaluation method because they do not use IT, or they evaluate their IT investments using oral and/or subjective instructions. In real life very few, if any, companies do not use IT, so the earlier option is not realistic. Companies that primarily use oral and/or subjective instructions on a few IT investments should choose a simple method that does not require specific knowledge and experience of completing IT evaluations.
- **Occasional**
  In this level companies should choose a method that is simple but where the small amount of knowledge and experience can be used with advantage in the IT evaluation. The method does not have to be used in several stages of the IT investment's lifecycle as the IT evaluation is completed as a one-off event.
- **Defined**
  If a company is placed in this level, it has some written guidelines for its IT evaluation practice. The choice of method should therefore focus on those that are using formal IT evaluation procedures and can use the knowledge and experience achieved in the earlier IT evaluations completed by the company.
- **Controlled**
  The choice of method should, on this level, be focused on methods that either support the company's written guidelines or upon which the guidelines are based. The method(s) should

enable a comparison between the ex-ante and ex-post evaluation, and should strengthen the company's knowledge and experience of IT evaluations.

- **Optimised**
  In the last level the choice of method should be integrated with the company's written guidelines. The method(s) should be capable of linking and comparing the evaluation output throughout the IT investment's lifecycle. A continuous improvement of the method(s) and the IT evaluation process should be possible.

## 10.3 The combined table

The combination of the previous tables, that describe the relationship between the attributes within the group of parameters called, *Company,* and the four methods, into one table can be found in *Table 31*.

Some of the earlier parameters (especially the first five) in this group does not significantly limit the number of useful methods, because these parameters are defined so broadly that it is difficult to conclude that some of the methods are not useful.

*Table 31. Company dependent parameters contra the four IT evaluation methods*

| | Reference | NPV | MBITI | IE | CSF |
|---|---|---|---|---|---|
| **Type of Company** | | | | | |
| Building material supplier | 9.1.1 | X | X | X | (X) |
| Architect | | | X | X | X |
| Consulting engineer | | | X | X | X |
| Contractor | | (X) | X | X | X |
| **Company Size** | | | | | |
| Small | 9.1.2 | X | X | | X |
| Medium | | (X) | X | X | X |
| Large | | (X) | X | X | X |
| **Company position** | | | | | |
| Leader | 9.1.3 | | (X) | X | (X) |
| Follower | | | X | X | X |
| Lagger | | (X) | | | X |
| **Business Strategy** | | | | | |
| Cost leadership | 9.1.4 | X | X | X | (X) |
| Differentiation | | | (X) | X | X |
| Cost focus | | X | X | X | (X) |
| Differentiation focus | | | (X) | X | X |
| **Decision Environment** | | | | | |
| No standards and procedures | 9.1.5 | X | X | X | X |
| General guidelines | | X | (X) | X | (X) |
| Written standards and procedures | | X | (X) | X | (X) |
| **Role of IT** | | | | | |
| Support | 9.1.6 | X | (X) | | X |
| Turnaround | | | X | X | |
| Factory | | X | (X) | (X) | X |
| Strategic | | X | X | X | X |
| **IT Maturity** | | | | | |
| Not applicable | 9.1.7 | (X) | | | (X) |
| Occasional | | X | (X) | | X |
| Responsive | | X | X | (X) | X |
| Planned | | X | X | X | X |
| Strategic | | X | X | X | X |
| Integrated | | X | X | X | X |
| **IT Evaluation Practice** | | | | | |
| Ad hoc | 9.1.8 | (X) | | | X |
| Occasional | | X | (X) | | X |
| Defined | | X | X | (X) | X |
| Controlled | | X | X | X | X |
| Optimised | | X | X | X | X |

## 10.4 The relationship between the attributes and the methods in IT evaluation

The relationship between the parameters' attribute(s) and the four IT evaluation methods in the group called, *IT evaluation*, is described in the following.

### 10.4.1 Purpose of IT evaluation

The relationship, as shown in *Table 32*, between the purpose for completing the IT evaluation and the four methods, is primarily based on the methods' need for inputs and the delivered output. For example, considering the purpose, *Manage an IT investment*. It is necessary to input empirical data (data representing an actual progress), and the output need to present a detailed picture of how the IT investment's progress is, and this is done best if the output is multiple. All the methods have some strengths and weaknesses in relation to the four purposes defined in chapter 9. Some of them have even been developed specifically for fulfilling one of the four IT evaluation purposes.

*Table 32. Relationship between Purpose of IT evaluation and the four IT evaluation methods*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **Purpose of IT Evaluation** | | | | |
| Identify the best IT investment | X | (X) | X | (X) |
| Evaluate impact from IT investment | X | X | X | |
| Manage IT investment | | X | (X) | X |
| Increase knowledge, skill and experience of IT evaluation | X | X | X | X |

The influence on choice of IT evaluation method is, for each of the four purposes, described below.

- **Identify the best IT investment**
  The first purpose indicates that more than one IT investment has to be evaluated and that they then will be compared with regard to the evaluation output. The last step is the prioritisation of the evaluated IT investments so that the highest scoring is ranked first. The input to the IT evaluation is based on estimates rather than actual measurements. The choice of IT evaluation method would therefore have to focus on the ability to compare the IT evaluation output (based on estimates) for different IT investments, and this is done best if the output of the method is single in nature.

  Two of the cases (NIRAS and H&S) used this purpose in their IT evaluation. Both of the IT evaluations were completed on the basis of estimates as input, but they also had some experience in using the technology from earlier work which occasionally provided input to the IT evaluation. Comparing the IT investments was done most easily using methods that provided a single output.

- **Evaluate the impact of the IT investment**
  Having this purpose for the IT evaluation indicates that only one IT investment is evaluated. The main activity is evaluating the IT investment for the company, in most cases, based on estimates. The value is very dependent on the IT evaluation criteria used and should therefore be chosen so it supports this activity. To do this will require an ability to analyse the resources spent, and compare them with the impact on the company using the IT investment.

Two cases (Rambøll and TJAS) were pursuing this purpose for their IT evaluations. At the time of the IT evaluations (implementation stage for both case studies), the impact of the applications was evaluated by estimating the costs and benefits given by the existing and expected conditions. The need for detailed output that enable an overview of the impact from the IT investment, was found to be beneficial.

- **Managing the IT investment**
  If a company evaluates an IT investment for this purpose it will focus on one IT investment in which the current status is identified. The IT evaluation's output will provide the IT evaluation champion(s) with an assessment of the IT investment's status/progress at the evaluation time with regard to the criteria used. The choice of IT evaluation method is almost similar to the previous purpose, but the usage of the output is different and may in some cases mean a difference in choice of method.

  The case study with Cowi evaluated the progress of their IT investment: DWS. Like the case studies with Rambøll and TJAS (described above) detailed output were found as beneficial for this purpose.

- **Increasing the knowledge, skill and experience in IT evaluation**
  The last purpose is, in several senses, different to the first three. The important aim is not the IT evaluation output but the process of completing the IT evaluation. The choice of IT evaluation method will therefore depend on different reasons than were stated in the previous purposes. The method should be chosen on the basis of the company's current level of IT evaluation practice, and the two possible sub-attributes either use a method corresponding to their current level (so they can improve the knowledge, skill and experience by using such a method), or to increase the level by using a more advanced method (this will enable the company to get an insight into IT evaluation by using a more advanced method).

  Three out of five case studies (Rambøll, Cowi and H&S) were completing the IT evaluation for this purpose. The reason for this was that the companies used the case studies as an opportunity for improving their knowledge and experience. All four methods were seen as a tool to fulfil this purpose which supports the fact that they can be used to increase the knowledge, skill and experience in conducting IT evaluations.

### 10.4.2 IT evaluation criteria

The crosses in *Table 33* are derived from the characteristics of the four methods that can be found in chapter 3. Most notable is that two criteria, *Quality improvements* and *External satisfaction,* are not supported in any of the four methods. The method, CSF, supports the criterion, requirements, whereas the other criterion included, end-user satisfaction, is not directly supported but may indirectly be assessed using the method.

*Table 33. Relationship between IT evaluation criteria and the four IT evaluation methods*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **IT Evaluation Criteria** | | | | |
| Financial | X | X | X | |
| Strategic | | X | X | |
| Competitive | | | X | |
| Effectiveness of use | | X | | |
| Quality improvements | | | | |
| Requirements | | | | X |
| End-user satisfaction | | | | (X) |
| External satisfaction | | | | |
| Technology | | | X | |
| Risk | | X | X | |

The most used criterion in the case studies was *Financial* (all five case studies). Many of the available methods are focused on this criterion (this is also reflected in *Table 33*). Three of the case studies were also focusing on other criteria like strategic value, requirements and risk.

### 10.4.3 Format of output

The first part of *Table 34* is focused on the type of output from the methods and the second part on the multiplicity of the methods' output. Both parts are derived from the characteristics of the four methods (for a more detailed description of the methods see chapter 3).

*Table 34. Relationship between Format of Output and the four IT evaluation methods*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **Format of Output** | | | | |
| Financial | X | X | X | |
| Ratio | | X | X | |
| Qualitative | | X | X | X |
| Requirements | | | | X |
| | | | | |
| Single | X | | (X) | |
| Multiple | | X | X | X |

Only a few of the case study companies had decided more precisely which format of output they wished as a result of the IT evaluation. Most of the case study companies were focused, however, on evaluating the financial value. Rambøll was focused on the more qualitative output, as they expected that the financial value would not show a positive output.

The main experience from the case studies regarding the multiplicity of the output was related to the detail level. Some of the case study companies were interested in the overall value of the IT investment, where others were interested in the details. H&S was comparing two alternative IT investments, which is best done by using methods that provide a single output. The IT evaluation champion in this case study did, however, say that the methods with the detailed output were the most revealing. Cowi were most interested in methods that provided detailed output, primarily because they wanted to be able to develop a monitoring plan to achieve the financial benefits.

### 10.4.4 IT evaluation champions

*Table 35*'s content is derived on the basis of the organisational levels' data accessibility and the methods' data requirements. In general the levels' data accessibility can be described as going from data representing the company's overall status (strategic), to data about managerial issues (tactical), to detailed data representing the actual working procedures (operational). The methods' data requirements are analysed and from that the relationship between the parameter's attributes and the methods is determined.

*Table 35. Relationship between IT evaluation champion(s) and the four IT evaluation methods*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **IT Evaluation Champion(s)** | | | | |
| Operational | (X) | | | (X) |
| Tactical | X | X | X | X |
| Strategic | X | | X | X |

Depending on which of the three company levels the IT evaluation champion(s) are placed might have some influence on the choice of method. The influences are described in the following.

- **Operational**
  In IT evaluations where the champion(s) is/are placed on the operational level, it implies that the requirements for the IT investment need to be identified. The complexity of the IT evaluation method will also have to be small, because the employees from this level are not familiar with IT evaluations, and the data available is focused on operational characteristics. The choice of method will therefore have to fulfil these aspects.

  None of the IT evaluation champion(s) in the case studies were primarily from the operational level, although this was a part of their job for a few of them.

- **Tactical**
  If the IT evaluation champion(s) is/are from the tactical level of the company, it generally implies that the IT evaluation is either making an IT investment proposal for approval by the strategic level, or to manage the IT investment. This level does most of the IT evaluation. The choice of method needs therefore to be a method that is suitable for one of these purposes. In order to enable a more detailed picture of the tactical level's managerial tasks, two sub-attributes are defined.
    - IT investment proposal
    - Managing IT investment

  All five case studies were completed with IT evaluation champions, who were categorised as belonging to the tactical level. These are, as defined, working daily with management tasks either related to building projects or IT. The IT evaluation champions had, in general, a high level of knowledge of the company's business activities and usage of IT (some on a user level and others on an expert level). The case studies were affected by a bias towards methods that provide detailed output.

- **Strategic**
  When the IT evaluation champion(s) is/are from the strategic level, then the IT evaluation in most cases would be focused on the strategic aspects of the IT investment. Furthermore the IT evaluation method should not be troubled with a high detail level because this is too time

consuming and will not produce useful output when the IT evaluation champion(s) is/are at this level. The data available to the strategic level also implies a need for methods that use that kind of data. The choice of method would therefore have to be from methods that support these aspects.

None of the case study companies' IT evaluation champions were from this level.

### 10.4.5 User of the IT evaluation

One aspect is relevant for determining the relationship between the parameter's attribute and the methods. The users of the IT evaluation, on the three respective organisational levels, require different types of output in order to support their main activity.

*Table 36. Relationship between User of IT evaluation and the four IT evaluation methods*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **User of IT Evaluation** | | | | |
| Operational | | X | | X |
| Tactical | X | X | X | X |
| Strategic | X | | X | |

The influence on choice of method is, for each of the three levels, described in the following.

- **Operational**
  The level, *Operational*, is rarely in practice the user of the IT evaluation. In cases where the user is from the operational level the main use of the IT evaluation output is informing the employees about the plans for IT and the current usage of the company's IT systems. The operational level is not generally working with decision making or IT management, and the IT evaluation methods' requirements are therefore not the same as for the two other company levels. The choice of method is therefore focused on methods that give the user from the operational level an overview of the current status of the evaluated IT investment.

  None of the five IT evaluations had the operational level as user.

- **Tactical**
  A significant part of an IT manager's activities is focused on managing the new IT investment and maintaining the existing IT systems and, whenever an IT evaluation is completed with the tactical level as user, it is done for these purposes. The requirements for the IT evaluation methods are therefore detailed and explicit output that the user can use to fulfil these purposes. The choice of IT evaluation method is therefore focused on methods that produce detailed output useful for management tasks.

  The tactical level was, in three of the case studies, identified as the user of IT evaluation. The main usage of the methods' output was found to be about getting a better insight into the IT investment's value (primarily the economic costs and benefits). All the methods provided a better insight according to the users. MBITI and IE were the most preferred.

- **Strategic**
  Most IT evaluations, completed with the strategic level as user, are for support of decision making. Typically the strategic level focuses on financial, strategic, competitive aspects of IT investments, whereas the detailed technical aspects are less relevant. The IT evaluation

output should be easily interpreted and support the strategic level's information need. The choice of IT evaluation method should therefore be from methods that produce simple output which support and present information related to subjects like financial, strategic and competitive value.

Four of the IT evaluations were originally planned to be presented at the strategic level (Rambøll, Cowi, NIRAS and H&S) but, of these, only two were actually presented. The reasons for this were, in one company, because of wrong output from the IT evaluation method and, in the other company, because they made some decisions which implied that the IT evaluation became obsolete. In the two cases, where the methods were presented, NPV and IE were preferred and lead to most discussion.

### 10.4.6 Cost of IT evaluation

The relationship between the parameter's attributes and the four methods is derived from the amount of resources needed to complete them. Although there was no direct attempt to document the resources needed for each method, the case studies provided the necessary information. The cost of the methods is highly related to their complexity and, in general, the more complex a method the higher cost. This relationship is shown in *Table 37*.

*Table 37. Relationship between Cost of IT evaluation and the four IT evaluation methods*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **Cost of IT Evaluation** | | | | |
| Inexpensive | (X) | | | X |
| Moderate | X | (X) | (X) | X |
| Expensive | | X | X | |
| Very expensive | | X | X | |

This issue was not directly addressed in the case studies but some experience was gained through the completion of the IT evaluation methods in terms of resources needed to collect the needed input. Many resources were spent on identifying and estimating the costs and benefits that are input to three of the four methods (NPV, MBITI and IE). Both MBITI and IE needed some extra data compared to NPV and some of these were very resource demanding to collect. CSF was, in all the case studies, experienced as less resource demanding and is therefore the cheapest method to complete (this depends of course on how many stakeholders are interviewed).

### 10.4.7 Difficulty of IT evaluation method

The crosses in *Table 38* are primarily derived on the basis of the methods' complexity in the same way as for the parameter, *Cost of IT evaluation*.

*Table 38. Relationship between Difficulty of IT evaluation method and the four IT evaluation methods*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **Difficulty of IT Evaluation Method** | | | | |
| Low | (X) | | | X |
| Moderate | X | X | | X |
| High | (X) | X | X | |
| Very high | | | X | |

Completing the five case studies using the four IT evaluation methods gave some data on each of the methods' difficulties. Some critical problems are still difficult even though these methods are used. The most complex and resource demanding method is, without doubt, IE. This is because the amount and type of data is high and difficult to collect. For example four out of five case studies were not able to collect data used in IE's concept called Value Restructuring. At the other end of the scale the easiest method is CSF (although some resources need to be spent on meetings with stakeholders). The people involved in collecting data for this method did not find it difficult compared to some of the other methods.

## 10.5 The combined table

The seven previous tables, that are describing the relationship between the parameters' attributes and the four methods within the group of parameters called, *IT evaluation*, have been combined into one table as seen in *Table 41*.

Viewing the relationship between the parameters and the four methods, it is worth noticing that two of the attributes (in the parameter, *IT evaluation criteria*) are not found useful or usable by any of the four methods. This indicates that the four methods are not able to fulfil these two attributes, and means that, in some cases, the choice of method must be identified from those not included in the framework.

*Table 39. IT evaluation dependent parameters contra the four IT evaluation methods*

| | Reference | NPV | MBITI | IE | CSF |
|---|---|---|---|---|---|
| **Purpose of IT Evaluation** | | | | | |
| Identify the best IT investment | 9.2.1 | X | (X) | X | (X) |
| Evaluate impact from IT investment | | X | X | X | |
| Manage IT investment | | | X | (X) | X |
| Increase knowledge and skill | | X | X | X | X |
| **IT Evaluation Criteria** | | | | | |
| Financial | 9.2.2 | X | X | X | |
| Strategic | | | X | X | |
| Competitive | | | | X | |
| Effectiveness of use | | | X | | |
| Quality improvements | | | | | |
| Requirements | | | | | X |
| End-user satisfaction | | | | | (X) |
| External satisfaction | | | | | |
| Technology | | | | X | |
| Risk | | | X | X | |
| **Format of Output** | | | | | |
| Financial | 9.2.3 | X | X | X | |
| Ratio | | | X | X | |
| Qualitative | | | X | X | X |
| Requirements | | | | | X |
| | | | | | |
| Single | | X | | (X) | |
| Multiple | | | X | X | X |
| **IT Evaluation Champion(s)** | | | | | |
| Operational | 9.2.4 | (X) | | | (X) |
| Tactical | | X | X | X | X |
| Strategic | | X | | X | X |
| **User of IT Evaluation** | | | | | |
| Operational | 9.2.5 | | X | | X |
| Tactical | | X | X | X | X |
| Strategic | | X | | X | |
| **Cost of IT Evaluation** | | | | | |
| Inexpensive | 9.2.6 | (X) | | | X |
| Moderate | | X | (X) | (X) | X |
| Expensive | | | X | X | |
| Very expensive | | | X | X | |
| **Difficulty of IT Evaluation Method** | | | | | |
| Low | 9.2.7 | (X) | | | X |
| Moderate | | X | X | | X |
| High | | (X) | X | X | |
| Very high | | | | X | |

## 10.6 The relationship between the attributes and the methods in IT investment

In the following the last group of parameters called, *IT investment*, are described with regards to the relationship between the attributes and the four methods.

### 10.6.1 Type of IT investment

The general trend in *Table 40* can be described as follows. The higher the rung of IT investment (see chapter 9) the more complex methods are needed. For IT investment on rung 2 and 3 the emphasis is more on quantitative aspects than the qualitative, and therefore NPV and MBITI are the best methods. The following rungs require more complex methods which focus not only on financial aspects. None of the methods are well suited for inter-organisational IT investment, however, CSF can be used in this context.

*Table 40. Relationship between Type of IT investment and the four IT evaluation methods*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **Type of IT Investment** | | | | |
| Mandatory changes | X | X | X | X |
| Automation | X | X | | |
| Direct value added | X | X | (X) | |
| MIS and DSS systems | | X | X | (X) |
| Infrastructure | | X | X | X |
| Inter-organisational | | (X) | (X) | X |
| Strategic systems | | (X) | X | X |
| Business transformation | | | X | X |

The five case studies represent a wide variety of types of IT investment in: *Automation*, *Infrastructure*, *Inter-organisational* and *Strategic systems*. One case study's IT investments were categorised as automation, which means, according to the table, that either NPV or MBITI should be used. In the other IT investments, which are categorised on higher rungs, the method NPV is not recommended.

The choice of IT evaluation method is described based on the dependence of the parameter, *Type of IT investment*.

9. **Mandatory changes**
   The first type of IT investment is not directly related to the type of technology, but more to the necessity of the IT investment. The choice of method should therefore focus on methods that highlight the IT investment's abilities to fulfil or satisfy the characteristics that are considered necessary (the reasons why the IT investment is mandatory). All four methods are therefore considered as useful.
10. **Automation**
    IT investments of this type focus on increasing the efficiency of existing working procedures. The choice of method is therefore from methods that evaluate the efficiency gains of the automation process.
11. **Direct value added**
    This type of IT investment increases the value of the affected business activities by doing things not done before. The choice of method is therefore from methods that can both evaluate the efficiency gains of the existing business activities, and the value of the new business activities to the company.

12. **MIS and DSS systems**
    IT investments, that are categorised as belonging to this rung, are improving the availability of information for planning, control and decision making activities. The choice of method is therefore from methods that evaluate the value of the improved information availability. An important issue of this type of IT investment is that the value is only achieved if the end users are capable of generating a value from the improved information availability.
13. **Infrastructure**
    Infrastructure IT investments are, in themselves, not generating a value to the company, but may allow other value-adding IT investments to be implemented in the future. The choice of method is therefore from methods that can evaluate the increased capabilities.
14. **Inter-organisational systems**
    Linking two or more organisations together through an IT investment is by Inter-organisational systems. Inter-organisational systems may mean a higher dependency on external relations, but they may also mean an improved ability to collaborate with external customers, partners and suppliers. The choice should therefore focus on methods that can evaluate the value of inter-organisational links.
15. **Strategic systems**
    IT investments, that are categorised as belonging to this group, fulfil the company's strategic plans (primarily business strategy). Strategic systems are not defined with regard to the technology used, but more to the role of the IT investment. The choice of method is therefore from methods that evaluate the IT investment's fulfilment of the strategic plans.
16. **Business transformations**
    The last type of IT investment impact is about transformation of the business' core activities. Evaluating IT investments of this kind is very extensive and requires an extraordinary IT evaluation method or, in most cases, several complementary methods. The choice should therefore be from methods that supplement each other so that the business transformation is evaluated.

### 10.6.2 Size of IT investment

The relationship between the parameter, *Size of IT investment*, and the four IT evaluation methods is that the larger the IT investment is the more detailed the method required. *Table 41* shows this relationship.

*Table 41. Relationship between Size of IT investment and the four IT evaluation methods*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **Size of IT investment** | | | | |
| Small | X | | | X |
| Moderate | X | X | X | X |
| Large | (X) | X | X | X |
| Very large | | X | X | X |

The influence of choice of IT evaluation method is, for each of the four attributes, described below.

- **Small**
  The level of detail in the IT evaluation is less relevant for this size of IT investment because the resource level is not regarded as a critical element in the IT evaluation. Useful methods are therefore NPV and CSF, as their detail level is relatively low.

  The case study with NIRAS evaluated an IT investment where the resource level was judged

as small. The data from this case study was very sparse, as only CSF was completed, and little can be concluded about the relationship between the attribute and the methods on the basis of this case study.

- **Medium**
  Medium size IT investments require a moderate level of detail in the IT evaluation. All the methods are useful in fulfilling the requirements from this size of IT investment, primarily because they can all be used to provide a moderate level of detail.

  Three out of five case studies (Rambøll, H&S and TJAS) are characterised as evaluating a medium sized IT investment. In these case studies it was revealed that the level of detail provided by the four methods was considered adequate.

- **Large**
  This attribute, where IT investments are characterised as requiring a significant level of resources, the useful methods are almost the same as in the previous attribute. NPV is considered as enabling a less detailed IT evaluation compared to the need identified in this attribute, whereby NPV is considered as usable but not useful.

  One case study (Cowi) was characterised as having a large IT investment. It was during the completion of the four methods identified, that NPV was found to be the only method that did not provide the desired detail level.

- **Very large**
  The last attribute, that includes very large sized IT investments, requires an extensive detail level in order ensure that the IT investment fulfils the expectations. MBITI, IE and CSF are capable of providing a high detail level and are therefore considered as useful, whereas NPV is not useful.

  None of the five case studies were evaluating IT investments of this size.

### 10.6.3 Purpose of IT investment

The relationship between the parameter, *Purpose with IT investment*, and the four IT evaluation methods is shown in *Table 42*.

*Table 42. Relationship between Purpose with IT investment and the four IT evaluation methods*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **Purpose with IT Investment** | | | | |
| Automate | X | X | (X) | |
| Informate | | X | X | (X) |
| Transformate | | (X) | X | X |

The crosses in *Table 42* represent the fact that the purpose of IT investment is ascending from a quantifiable value (well-known) to a more qualitative value (unknown) for the attributes.

The influence on the choice of method for each the three attributes defined above is described in the following.

- **Automate**
  For IT investments, where the main purpose is automation, the choice of method should be from methods that can evaluate the value of the now automated business activities compared to the traditional (labour intensive) business activities. The changes from the automation exercise are often well defined and result in mainly quantitative benefits. Financial IT evaluation methods are therefore considered as useful if this attribute is chosen.

  Two of the case studies (Rambøll and NIRAS) evaluated IT investments the primary purpose of which is characterised as automating some of the company's business activities (this is also reflected in the previous section). Usually most of the benefits achieved from these IT investments are tangible and can be evaluated by the financial and quantitative methods.

- **Informate**
  For this attribute, where IT investments enable an increased value of the companies' business activities, the IT evaluation should focus on highlighting the value of this change to the company. To highlight the increased value, it should be compared to the value of the traditional business activities. The choice of method needs to be able to evaluate the improved information available.

  Three of the IT investments (Cowi, H&S and TJAS) evaluated are categorised in this group. These three are categorised in different types of IT investment (see previous section). The common experience from these cases was the difficulty of evaluating especially the benefits, because many of them are intangible in nature. NPV did not include these benefits and this clearly gave a wrong picture of the IT investment. In the case with TJAS, NPV gave a positive output, but this could have been better if the intangible benefits were taken into consideration as well.

- **Transformate**
  The last attribute consists of IT investment of which the purpose is to transform the company's business activities. The choice of method should therefore be focused on methods that evaluate new business activities. There are no comparison possibilities in the IT evaluation.

  None of the evaluated IT investments are categorised in this group.

### 10.6.4 IT investment's domain

*Table 43* shows the relationship between the parameter, *IT investment domain*, and the four IT evaluation methods.

*Table 43. Relationship between IT investment domain and the four IT evaluation methods*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **IT Investment Domain** | | | | |
| Person | X | | | X |
| Department | X | X | X | X |
| Company | X | X | X | X |
| Building project | (X) | (X) | | X |

The table shows that CSF can be used at any of the defined levels, whereas NPV can, with some difficulty, be used from a building project point of view. Both MBITI and IE are designed with the purpose of evaluating IT investments on a department or company level, which is the reason why they should be used at the other levels.

Four out of five of the case studies (Rambøll, Cowi, NIRAS and TJAS) were done either using a department or company point of view and it was found that all four methods were capable of evaluating the IT investment in that domain. The fifth case study, with H&S, completed the IT evaluation within the domain called, *Building project*. It was found that IE was less useful for fulfilling this requirement as it is very much based on a company point of view.

### 10.6.5 Stage of IT investment

The relationship between the parameter's attributes and the methods is derived from two characteristics of the stage of IT evaluation. First, the data available to be input into the IT evaluation method, and second the purpose of the IT evaluation which, in some cases, may be related to the stage of the IT evaluation. It is notable, in stages 3 and 4 (see *Figure 40*), that none of the four methods are useful for evaluating the IT investment at this stage, however, both MBITI and CSF are useable when evaluating the current progress of the IT investment.

*Table 44. Relationship between Stage of IT evaluation and the four IT evaluation methods*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **Stage of IT Evaluation** | | | | |
| Consider new IT investment | X | (X) | X | X |
| Decide IT system | X | X | X | |
| Develop IT system | | (X) | | (X) |
| Implement IT system | | (X) | | (X) |
| Use of IT system | | X | | |
| Upgrade or abandon IT system | (X) | X | X | |

The case studies represent a broad range of stages as defined in this parameter. In the case study with NIRAS (stage: *Consider new IT investment*) it was found difficult to use the quantitative methods (including NPV) but, in general, it is argued that three out of four methods are useful. The four other cases (representing the stages: *Decide IT system*, *Use of IT system* and *Upgrade or abandon IT system*) indicated that CSF was of little use in these stages. MBITI is the only method that was useful in the stage: *Use of IT system*, because of its focus on measuring the IT investment's benefits.

### 10.6.6 Importance of IT evaluation

The choice of IT evaluation method, as indicated in Table 45, will be among methods that evaluate IT investments with a corresponding level of detail and allowed cost of the IT evaluation, compared to the level of importance of the IT investment to the company.

*Table 45. Relationship between Type of costs/benefit from IT investment and the four IT evaluation methods*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **Importance of IT Investment** | | | | |
| Low | X | (X) | | X |
| Moderate | X | X | (X) | X |
| High | | X | X | (X) |
| Very high | | (X) | X | (X) |

Only in one of the case studies (Cowi) the importance of the IT investment was categorised as high. In this case the IT evaluation champions allowed a high cost of the IT evaluation, and their emphasis on completing a detailed evaluation was evidently high. In the other four case studies the evaluated IT investments had a moderate importance.

## 10.7 The combined table

Like the case with the two other groups of parameters the tables in *IT investment*, are combined into one table as seen in *Table 46*.

The last table shown, *Table 46*, that combines the previous six tables, reveals that none of the methods are useful when evaluating an IT investment during the stages; *Develop IT system* and *Implement IT system*. This means that, if this parameter is judged as very important, then the method has to be found from those not included in the tables.

*Table 46. IT investment dependent parameters contra the four IT evaluation methods*

| | Reference | NPV | MBITI | IE | CSF |
|---|---|---|---|---|---|
| **Type of IT Investment** | | | | | |
| Mandatory changes | 9.3.1 | X | X | X | X |
| Automation | | X | X | | |
| Direct value added | | X | X | (X) | |
| MIS and DSS systems | | | X | X | (X) |
| Infrastructure | | | X | X | X |
| Inter-organisational | | | (X) | (X) | X |
| Strategic systems | | | (X) | X | X |
| Business transformation | | | | X | X |
| **Size of IT investment** | | | | | |
| Small | 9.3.2 | X | | | X |
| Medium | | X | X | X | X |
| Large | | (X) | X | X | X |
| Very large | | | X | X | X |
| **Purpose with IT Investment** | | | | | |
| Automate | 9.3.3 | X | X | (X) | |
| Informate | | | X | X | (X) |
| Transformate | | | (X) | X | X |
| **IT Investment's Domain** | | | | | |
| Person | 9.3.4 | X | | | X |
| Department | | X | X | X | X |
| Company | | X | X | X | X |
| Building project | | (X) | (X) | | X |
| **Stage of IT Evaluation** | | | | | |
| Consider new IT investment | 9.3.5 | X | (X) | X | X |
| Decide IT system | | X | X | X | |
| Develop IT system | | | (X) | | (X) |
| Implement IT system | | | (X) | | (X) |
| Use of IT system | | | X | | |
| Upgrade or abandon IT system | | (X) | X | X | |
| **Importance of IT Investment** | | | | | |
| Low | 9.3.6 | X | (X) | | X |
| Moderate | | X | X | (X) | X |
| High | | | X | X | (X) |
| Very high | | | (X) | X | (X) |

## *10.8 Summary*

In this chapter 21 parameters and their attributes have been described in relation to the four IT evaluation methods.

The methods' usability in fulfilling the requirements identified for each of the parameters' attributes have been described by using three usability scores: **X**, **(X)** and **No Cross**, and are displayed in a series of tables throughout the chapter.

*Table 31*, *Table 39* and *Table 46* show three combined tables and these are the central elements in the framework described in chapter 11.

# Part IV

# Results

Two versions of the framework are presented and their usage is described. The two versions show how the framework can be implemented. The framework is tested with regard to the validity of its output and usefulness.

# Chapter 11: Using the framework

This chapter describes the implementation of the framework of which foundation has been described in the previous chapters. The primary objective in the framework is to select the best matching IT evaluation method. The best matching method is, in this context, referring to a match between the characteristics of the actual IT evaluation and four IT evaluation methods.

Two versions of the framework, a paper-based version and software-based version, have been developed in order to demonstrate how the framework can be implemented. The software-based version is only briefly presented in the first part of the chapter, whereas the paper-based version is, in the later sections of the chapter, used to explain the usage of the framework in more detail.

The second part of the chapter describes a paper-based version, which is directly based on the derived tables as described and shown in chapter 10). This includes a description of how the tool is structured and how it can be used to determine the best matching method depending on the characteristics of the IT evaluation. It furthermore includes a description of the aspects that are important for the use of the framework.

In the third part of the chapter a small example is described in which the paper-based version is used. This is done to illustrate how it should be used.

The fourth part of the chapter describes the possible output from using the framework, and a few comments on what can be concluded from the different types of output are included.

## 11.1 Assumptions and limitations in the framework

A few of the assumptions and limitations in the framework need to be commented on before it is used.

Using this framework allows a company, which has business with the construction industry, to select the best matching IT evaluation method using a range of predetermined parameters (which are described in detail in chapter 9).

The framework only identifies the IT evaluation methods that match the requirements in the specific situation for the targeted IT investment. This implies that the selected method may not be useful in another IT evaluation, even though it is the same company that is doing it, or if it is a similar IT investment evaluated by another company.

## 11.2 The software-based version

The software-based version of the framework was developed by using Kappa V. 2.4 (from Intellicorp). Kappa is an application that can be used to develop object-oriented software applications that represent knowledge, like for example expert systems[16].

In this thesis it has been used to develop a user-friendly version of the framework. User-friendly means that user's interaction with the framework is reduced to only inputting the necessary information by interaction with an easily understandable user interface. The software-based version

[16] Expert systems can be regarded as the embodiment of an expert skill within a computer, in such a form that the system can provide intelligent advices or take intelligent decisions about a processing function.

should be viewed as a prototype and therefore no attempt to implement help-functions, etc. have been made.

The software-based version was developed using the same structure as the paper-based version (see eventually the later sections in this chapter). The most significant difference between the two versions is that those activities, which the software-based version can complete automatically without requiring interaction from the user, have been implemented if possible.

The software-based version is named, SITEM, which is an abbreviation for, Selection of IT Evaluation Method. It consists of six sequenced linked screens, whereof four are shown in the following. A more detailed description of SITEM can be found in Appendix I1.

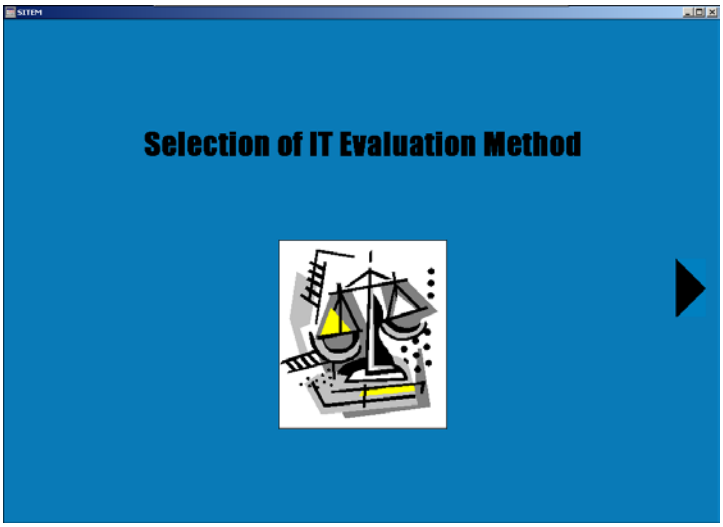



*Figure 42. Opening screen in SITEM*

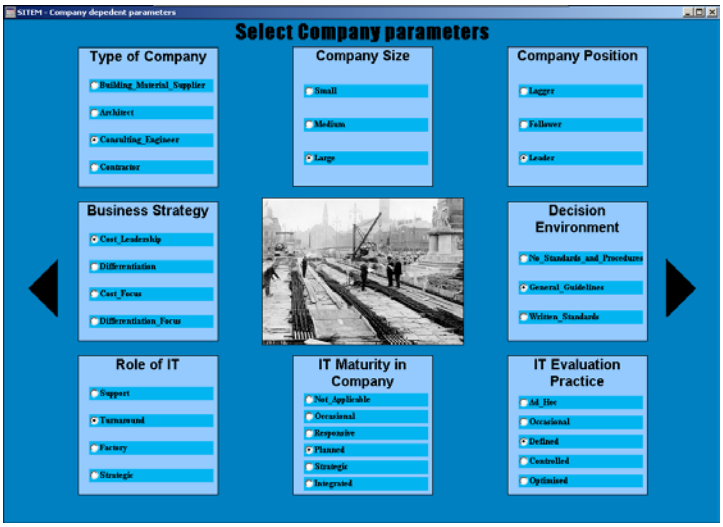



*Figure 43. Selecting the parameters' attribute(s) in Company in SITEM*

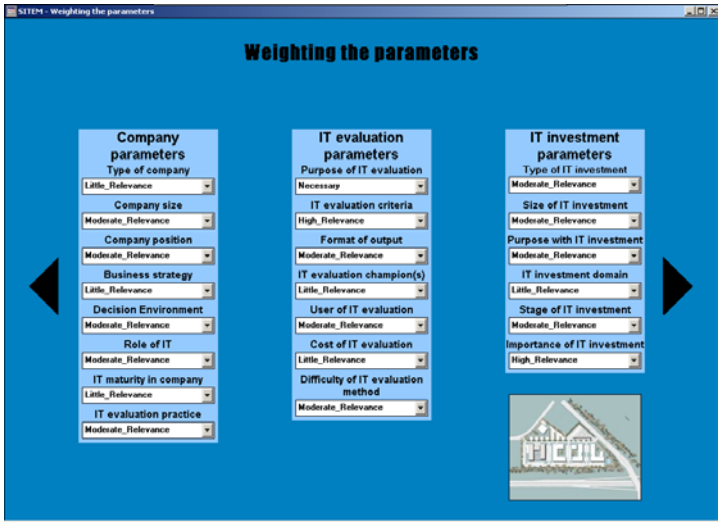



*Figure 44. Selecting each parameters' weight in SITEM*

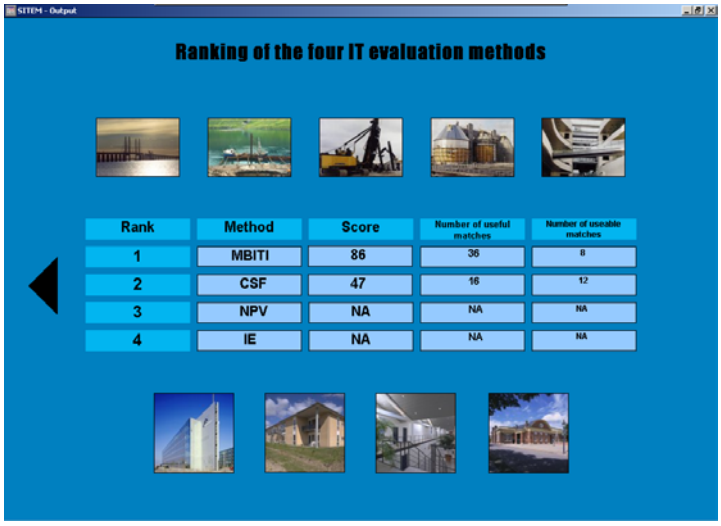



*Figure 45. The output screen from SITEM*

The differences between the paper-based and software-based versions are briefly commented on where appropriate in the presentation of the paper-based version in the following sections.

## 11.3 The paper-based version

This section describes the structure of the paper-based version by describing how the framework is used. A series of steps need to be initiated and completed in order to identify the best matching IT evaluation method (see also *Figure 46*).

- **Select the best matching attribute(s) in the parameters**
  The first step is about selecting the best matching attributes compared to the user's actual situation. This implies that the 21 parameters have to be assigned at least one attribute.
- **Select the parameters' weight**
  The second step is to give each parameter a weight based on its relative importance. A number of different weights can be assigned to the parameters as described further in section 11.3.2.

- **Combine the parameters' attributes and the weights**
  The third step is calculating the sum of the usability scores (**X**, **(X)** and **No Cross**) for each method in each of the three groups of parameters (*Company*, *IT evaluation* and *IT investment*). This step is completed without the user's interaction in SITEM.
- **Identifying the best matching method**
  On the basis of the usability scores, the best matching method can be identified by comparing the sum of the usability scores.

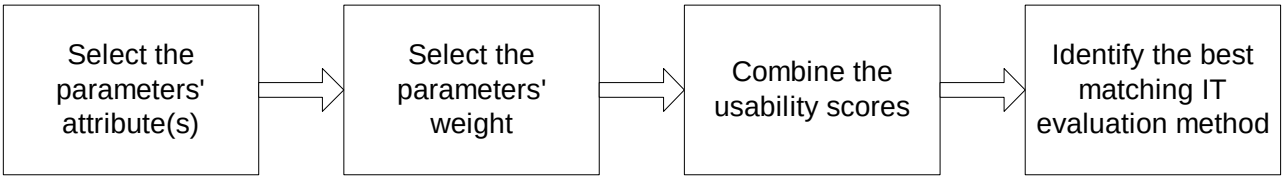



*Figure 46. The four steps when using the framework*

Each of the four steps is described in detail in the following.

### 11.3.1 Step 1: Select the parameters' attribute(s)

The first step is selecting the parameters' attributes so they represent the characteristics of the actual IT evaluation. In order to complete this step requires the user of the framework to be knowledgeable about the characteristics and requirements of the actual IT evaluation for which a method needs to be chosen.

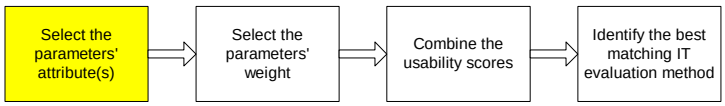



*Figure 47. Step 1: Selecting the parameters' attribute(s)*

For each of the defined parameters in the three tables at least one attribute needs to be selected so that they represent the characteristics of the actual IT evaluation. When selecting the attributes the user needs to be aware of the potential overlaps between them. The potential overlaps are described in chapter 9. In case of overlaps between the attributes, that the user has to reconsider the choice of attributes so the conflict is removed. The user of SITEM is warned whenever an inconsistent pair of attributes is chosen.

The three tables used for this purpose are seen in *Table 47*, *Table 48* and *Table 49*. The tables are almost identical to those presented in chapter 10. However, an extra column at the left has been added enabling the user of the framework to select (for example by using an X) the matching attribute(s) for each parameter (the other amendments to the tables are described in the later sections). When using SITEM the user needs to select the matching attributes by using the mouse.

For most of the parameters only one of the attributes needs to be selected, but for a few of the parameters several attributes can be chosen. This is indicated by the words: single or multiple stated next to the parameters' name. The opportunity to select several parameters does not necessarily means that several attributes have to be selected, as this should depend on the actual situation.

*Table 47. Parameters related to Company*

| Selected attribute | | Ref. | NPV | MBITI | IE | CSF | Weight |
|---|---|---|---|---|---|---|---|
| **Single** | **Type of Company** | | | | | | |
| | Building material supplier | 9.1.1 | X | X | X | (X) | |
| | Architect | | | X | X | X | |
| | Consulting engineer | | | X | X | X | |
| | Contractor | | (X) | X | X | X | |
| **Single** | **Company Size** | | | | | | |
| | Small | 9.1.2 | X | X | | X | |
| | Medium | | (X) | X | X | X | |
| | Large | | (X) | X | X | X | |
| **Single** | **Company position** | | | | | | |
| | Lagger | 9.1.3 | (X) | | | X | |
| | Follower | | | X | X | X | |
| | Leader | | | (X) | X | (X) | |
| **Single** | **Business Strategy** | | | | | | |
| | Cost leadership | 9.1.4 | X | X | X | (X) | |
| | Differentiation | | | (X) | X | X | |
| | Cost focus | | X | X | X | (X) | |
| | Differentiation focus | | | (X) | X | X | |
| **Single** | **Decision Environment** | | | | | | |
| | No standards and procedures | 9.1.5 | X | X | X | X | |
| | General guidelines | | X | (X) | X | (X) | |
| | Written standards | | X | (X) | X | (X) | |
| **Single** | **Role of IT** | | | | | | |
| | Support | 9.1.6 | X | (X) | | X | |
| | Turnaround | | | X | X | | |
| | Factory | | X | (X) | (X) | X | |
| | Strategic | | X | X | X | X | |
| **Single** | **IT Maturity** | | | | | | |
| | Not applicable | 9.1.7 | (X) | | | (X) | |
| | Occasional | | X | (X) | | X | |
| | Responsive | | X | X | (X) | X | |
| | Planned | | X | X | X | X | |
| | Strategic | | X | X | X | X | |
| | Integrated | | X | X | X | X | |
| **Single** | **IT Evaluation Practice** | | | | | | |
| | Ad hoc | 9.1.8 | (X) | | | X | |
| | Occasional | | X | (X) | | X | |
| | Defined | | X | X | (X) | X | |
| | Controlled | | X | X | X | X | |
| | Optimised | | X | X | X | X | |
| ***Subtotal*** | | | | | | | |
| | X | | | | | | |
| | (X) | | | | | | |
| | No Cross | | | | | | |
| | * | | | | | | |

*Table 48. Parameters related to IT evaluation*

| Selected attribute | | Ref. | NPV | MBITI | IE | CSF | Weight |
|---|---|---|---|---|---|---|---|
| **Multiple** | **Purpose of IT Evaluation** | | | | | | |
| | Identify the best IT investment | 9.2.1 | X | (X) | X | (X) | |
| | Evaluate impact from IT investment | | X | X | X | | |
| | Manage IT investment | | | X | (X) | X | |
| | Increase knowledge and skill | | X | X | X | X | |
| **Multiple** | **IT Evaluation Criteria** | | | | | | |
| | Financial | 9.2.2 | X | X | X | | |
| | Strategic | | | X | X | | |
| | Competitive | | | | X | | |
| | Effectiveness of use | | | X | | | |
| | Quality improvements | | | | | | |
| | Requirements | | | | | X | |
| | End-user satisfaction | | | | | (X) | |
| | External satisfaction | | | | | | |
| | Technology | | | | X | | |
| | Risk | | | X | X | | |
| **Multiple** | **Format of Output** | | | | | | |
| | Financial | 9.2.3 | X | X | X | | |
| | Ratio | | | X | X | | |
| | Qualitative | | | X | X | X | |
| | Requirements | | | | | X | |
| **Single** | | | | | | | |
| | Single | | X | | (X) | | |
| | Multiple | | | X | X | X | |
| **Single** | **IT Evaluation Champion(s)** | | | | | | |
| | Operational | 9.2.4 | (X) | | | (X) | |
| | Tactical | | X | X | X | X | |
| | Strategic | | X | | X | X | |
| **Single** | **User of IT Evaluation** | | | | | | |
| | Operational | 9.2.5 | | X | | X | |
| | Tactical | | X | X | X | X | |
| | Strategic | | X | | X | | |
| **Single** | **Cost of IT Evaluation** | | | | | | |
| | Inexpensive | 9.2.6 | (X) | | | X | |
| | Moderate | | X | (X) | (X) | X | |
| | Expensive | | | X | X | | |
| | Very expensive | | | X | X | | |
| **Single** | **Difficulty of IT Evaluation Method** | | | | | | |
| | Low | 9.2.7 | (X) | | | X | |
| | Moderate | | X | X | | X | |
| | High | | (X) | X | X | | |
| | Very high | | | | X | | |
| **Subtotal** | | | | | | | |
| | X | | | | | | |
| | (X) | | | | | | |
| | No Cross | | | | | | |
| | * | | | | | | |

*Table 49. Parameters related to IT investment*

| Selected attribute | | Ref. | NPV | MBITI | IE | CSF | Weight |
|---|---|---|---|---|---|---|---|
| Single | **Type of IT Investment** | | | | | | |
| | Mandatory changes | 9.3.1 | X | X | X | X | |
| | Automation | | X | X | | | |
| | Direct value added | | X | X | (X) | | |
| | MIS and DSS systems | | | X | X | (X) | |
| | Infrastructure | | | X | X | X | |
| | Inter-organisational | | | (X) | (X) | X | |
| | Strategic systems | | | (X) | X | X | |
| | Business transformation | | | | X | X | |
| Single | **Size of IT Investment** | | | | | | |
| | Small | 9.3.2 | X | | | X | |
| | Medium | | X | X | X | X | |
| | Large | | (X) | X | X | X | |
| | Very large | | | X | X | X | |
| Single | **Purpose with IT Investment** | | | | | | |
| | Automate | 9.3.3 | X | X | (X) | | |
| | Informate | | | X | X | (X) | |
| | Transformate | | | (X) | X | X | |
| Single | **IT Investment's Domain** | | | | | | |
| | Person | 9.3.4 | X | | | X | |
| | SBU/Department | | X | X | X | X | |
| | Company | | X | X | X | X | |
| | Building project | | (X) | (X) | | X | |
| Single | **Stage of IT Evaluation** | | | | | | |
| | Consider new IT investment | 9.3.5 | X | (X) | X | X | |
| | Decide IT system | | X | X | X | | |
| | Develop IT system | | | (X) | | (X) | |
| | Implement IT system | | | (X) | | (X) | |
| | Use of IT system | | | X | | | |
| | Upgrade or abandon IT system | | (X) | X | X | | |
| Single | **Importance of IT Investment** | | | | | | |
| | Low | 9.3.6 | X | (X) | | X | |
| | Moderate | | X | X | (X) | X | |
| | High | | | X | X | (X) | |
| | Very high | | | (X) | X | (X) | |
| ***Subtotal*** | | | | | | | |
| | X | | | | | | |
| | (X) | | | | | | |
| | No Cross | | | | | | |
| | * | | | | | | |

Having selected the appropriate attribute(s) in each parameter in the three tables the first step is completed.

### 11.3.2 Step 2: Select the parameters' weight

The second step in the framework is weighting each parameter's importance, as the user perceives them. A user will, in most cases, not consider the parameters are equally important and therefore they need to be weighted according to their perceived importance.

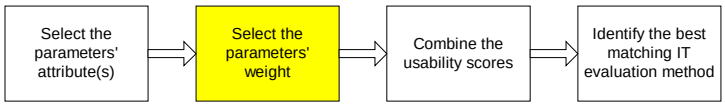



*Figure 48. Step2: Selecting the parameters' weight*

The weights of the parameters should, as a general rule, be identified every time the framework is used. This is primarily because the weights given should reflect the actual prioritising of the parameters' importance in the IT evaluation.

The weight given to a parameter should be regarded as a relative measure, implying that it reflects the importance of the parameter compared to the other parameters. This means that the weights given are not absolute measures, but is rather implying that some of the parameters are perceived as more important than others.

Each parameter is assigned a weight using a scale ranging from 0 to 3, where 0 is the lowest and 3 the highest. A fifth weight can be assigned to those parameters which the user considers as a necessity (means that the chosen method must fulfil the requirement) by using the symbol, *****.

The scale is briefly described in the following (the words in brackets are those used in SITEM).

- **0 (Irrelevant)**
  A weight of 0 indicates that the parameter is irrelevant compared to the other parameters. In other words if a parameter is given a weight of 0 it means that it has no influence on the choice of method at all.
- **1 (Little relevance)**
  This weight implies that the parameter is perceived as relevant but only to a very small degree compared to the other parameters. Parameters given this weight only influence the choice of method minimally.
- **2 (Moderate relevance)**
  A weight of 2 implies that the parameter is regarded as having a moderate relevance compared to the other parameters. Considering the scale used to weight the parameters this weight implies an average influence on choice of method.
- **3 (High relevance)**
  The last weight (3) is given to the parameters that are considered as the most important. In general those parameters given this weight should be fulfilled, but is not a necessity.
- *** (Necessary)**
  Parameters, that are marked with a *, are considered as an absolute requirement and must therefore be fulfilled by the method chosen. Only methods that fulfil this parameters attribute(s) (indicated by X in the tables), are regarded as usable.

Assigning a weight to each parameter is done by inserting the identified weight in the column farthest to the right of the table (in SITEM by clicking on the desired weight, see *Figure 44*).

Having assigned one weight to each parameter implies that step two is complete.

### 11.3.3 Step 3: Combine the parameters' attributes and the weights

The third step is to combine the selected attributes' usability scores for each method with the weights given for each parameter. This is a relatively straightforward task, as it only requires a minimum of mathematical ability (but a certain amount of discipline).

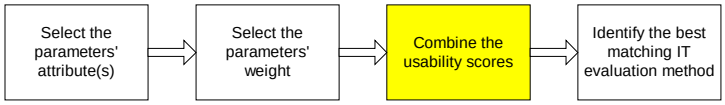



*Figure 49. Step 3: Combining the parameters' attribute(s) and the weights*

Before initiating the activities in this step it is necessary that all the parameters are assigned at least one attribute, and that they have been given a weight according to the scale defined in the previous section. The user is, when using SITEM, not able to do this step if not all parameters have been assigned at least one attribute and a weight.

For each of the selected attributes the method's usability score (either **X**, **(X)** or **No Cross**) is multiplied by the weight given to the parameter. The results of this are then summarised for each group of parameters (see eventually *Table 47*, *Table 48* and *Table 49*) and input to the *Subtotal* (see the bottom part of the three tables).

In case a parameter has been given a weight of, *****, and the method's usability score is **X,** then the method is marked by the symbol, **+**, in the last row of the table's *Subtotal*, but if the method has a usability score of **(X)** or **No cross** then the method is given the symbol, **-**. Assigning one of the symbols, + or -, indicates whether the method fulfils the necessary requirements.

The methods' usability scores in *Subtotal* can, by summing them up, be used as a control that the calculations are correctly completed. The sum of the usability scores should, for all the methods, be equal to the sum of the parameters' weights (in case several attributes have been selected in a parameter, the multiple of these should be included as well).

Having calculated the *Subtotal* of each method's usability scores in the three tables, then the third step of the framework is completed. When using SITEM this step is completed automatically without user interaction.

### 11.3.4 Step 4: Identifying the best matching method

The fourth and final step in completing the paper-based version is identifying the best matching IT evaluation method. This step is easily completed, as it only requires two activities. First, a calculation of the *Total* of the methods' usability scores and, second, comparing the methods' usability scores with each other.

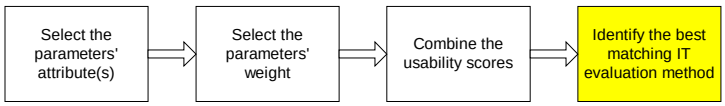



*Figure 50. Step 4: Identifying the best matching method*

The *Subtotal* of the methods' usability scores, as calculated in each of the three groups of parameters, are input in *Table 50*. Thereafter the *Total* is calculated by summing the methods' usability scores in *Table 50* (see bottom part of the table).

For the usability score, *****, it is not necessary to calculate the sum as this score should be considered as a Boolean measure (representing either a TRUE or FALSE state). This last row in *Total* should instead reflect whether the method fulfils all those parameters weighted as, *****. If the method fulfils

all the necessary requirements it should be assigned the symbol, +, if not, it should be assigned the symbol, -.

*Table 50*, when completed, provides the IT evaluation champion with a good overview of the methods' usability scores. This is done by displaying both the *Subtotals* and the *Total* of the four methods usability scores.

*Table 50. Output table showing the score for each method*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **Company** | | | | |
| X | | | | |
| (X) | | | | |
| No Cross | | | | |
| * | | | | |
| **IT Evaluation** | | | | |
| X | | | | |
| (X) | | | | |
| No Cross | | | | |
| * | | | | |
| **IT Investment** | | | | |
| X | | | | |
| (X) | | | | |
| No Cross | | | | |
| * | | | | |
| ***Total*** | | | | |
| X | | | | |
| (X) | | | | |
| No Cross | | | | |
| * | | | | |

Again the calculations made can be controlled by summing each methods' usability scores in the part of the table called, *Total*, which should be equal for all the methods.

The best matching IT evaluation method is identified by comparing the *Total* of the usability scores. The method with the highest *Total* is regarded as the best match and should therefore be chosen. The priority of the usability scores is first, **X**, and second, **(X)**, which means that the method with the highest *Total* of, **X**, should be regarded as the best match. This is valid unless another method is (almost) equal with regard to the *Total* of, **X**, and has a significantly higher *Total* of, **(X)** which implies that the method's usability scores in combination are higher than the first method.

In the extremely rare case that two or more methods have similar *Totals* of the usability scores, **X** and **(X)**, then these methods are regarded as equally useful and either of them can be chosen.

When using SITEM this step is completed automatically and provides the user with a ranking of the four methods as shown in *Figure 45*. An extra facility has been implemented in SITEM by calculating a total score of each method ranging between 0 and 100. The total score reflects the method's match with the best possible match achievable. This implies that methods achieving a total score of 100 have a perfect match with the parameters' attribute(s).

## 11.4 An example of using the framework

In order to illustrate how the four steps are completed in the paper-based version, a demonstration using a small example is completed. The example used is not based on an actual case study, nor is it a full-scale example, because the intention is only to illustrate how the four steps, as described above, are completed.

### 11.4.1 Description of mini-example

The IT evaluation is in this example is characterised by two aspects. First the IT investment, that is being evaluated, is currently used by the company in some of its business activities. The user therefore wants to identify whether it is able to generate the expected benefits. Second, in the evaluation the user is interested in the IT investment's financial value, strategic value and how effectively the IT investment is used.

The user does not know which method should be used in the evaluation of the IT investment and therefore completes the paper-based version of the framework. The chosen method should at least be able to support the primary objective of the IT evaluation as this is regarded as a necessary requirement. Of the benefits achieved from the IT investment the user is interested in those mentioned above, but they are not regarded as crucial for the evaluation because other types of benefit are also considered as relevant.

### 11.4.2 Select the best matching parameters' attribute(s)

The first step is selecting the attribute(s) that represent the actual IT evaluation. *Table 51* shows an extract of the group of parameters called, *IT investment*, from the paper-based version of the framework.

The first parameter in *Table 51* is, *Purpose of IT evaluation*, which has four attributes, of which more than one are allowed to be chosen (but not required). From the description of above example is derived what the purpose of the IT evaluation is, *Manage IT investment*, which, in the table, is indicated by inputting a cross to the respective cell (the cell is highlighted by an ellipse). Further information on the parameter and its attributes can be found in the section that is referred to in the third column (in this case the reference is found in section 9.2.1).

In the second parameter, *IT evaluation criteria*, the same approach is used. The company regards three IT evaluation criteria as interesting (Financial, Strategic and Effectiveness of use) as seen in the example. This is marked by putting a cross in the attributes as seen in the table (those highlighted by ellipses).

*Table 51. Extract of paper-based version – Selecting attribute(s)*

| Selected attribute | | Ref. | NPV | MBITI | IE | CSF | Weight |
|---|---|---|---|---|---|---|---|
| Multiple | **Purpose of IT Evaluation** | | | | | | |
| | Identify the best IT investment | 9.2.1 | X | (X) | X | (X) | |
| | Evaluate impact from IT investment | | X | X | X | | |
| X | Manage IT investment | | | X | (X) | X | |
| | Increase knowledge and skill | | X | X | X | X | |
| Multiple | **IT Evaluation Criteria** | | | | | | |
| X | Financial | 9.2.2 | X | X | X | | |
| X | Strategic | | | X | X | | |
| | Competitive | | | | X | | |
| X | Effectiveness of use | | | X | | | |
| | Quality improvements | | | | | | |
| | Requirements | | | | | X | |
| | End-user satisfaction | | | | | (X) | |
| | External satisfaction | | | | | | |
| | Technology | | | | X | | |
| | Risk | | | X | X | | |
| ***Subtotal*** | | | | | | | |
| | X | | | | | | |
| | (X) | | | | | | |
| | No Cross | | | | | | |
| | * | | | | | | |

In total four attributes in the two parameters have been selected. Having selected the parameters' attribute(s) the first step in the framework is completed.

### 11.4.3 Select the parameters' weight

The second step is selecting the parameters' weights. *Table 52* shows the table from the previous section but where the weightings assigned to the parameters are input as well (see the weights in farthest right column that are marked by ellipses).

Based on the description of the example, the two parameters in the table have been given a weight of ***** and **2** (for a more detailed description of the meaning of these weights see section 11.3.2).

The weight, *****, which has been given to the first parameter, is indicating that the chosen method has to fulfil this requirement. More specifically this means that only methods that have the usability score, **X**, in the respective attribute are useful and therefore all the other methods (not fulfilling this requirement) cannot be chosen.

The second parameter, *IT evaluation criteria*, has been assigned a weight of 2. This indicates that the parameter's weight, when choosing the method, is of moderate relevance when compared to the other parameters.

*Table 52. Extract of paper-based version – Weighting parameters*

| Selected attribute | | Ref. | NPV | MBITI | IE | CSF | Weight |
|---|---|---|---|---|---|---|---|
| **Multiple** | **Purpose of IT Evaluation** | | | | | | |
| | Identify the best IT investment | 9.2.1 | X | (X) | X | (X) | * |
| | Evaluate impact from IT investment | | X | X | X | | |
| X | Manage IT investment | | | X | (X) | X | |
| | Increase knowledge and skill | | X | X | X | X | |
| **Multiple** | **IT Evaluation Criteria** | | | | | | |
| X | Financial | 1.3.2 | X | X | X | | 2 |
| X | Strategic | | | X | X | | |
| | Competitive | | | | X | | |
| X | Effectiveness of use | | | X | | | |
| | Quality improvements | | | | | | |
| | Requirements | | | | | X | |
| | End-user satisfaction | | | | | (X) | |
| | External satisfaction | | | | | | |
| | Technology | | | | X | | |
| | Risk | | | X | X | | |
| ***Subtotal*** | | | | | | | |
| | X | | | | | | |
| | (X) | | | | | | |
| | No Cross | | | | | | |
| | * | | | | | | |

### 11.4.4 Combine the parameters' attributes and the weights

The third step is combining the parameters' attributes with the weights. *Table 53* is a continuation of the example shown in the previous sections where the last part of the table is filled out.

The first parameter was, in a previous section, assigned one attribute, *Manage IT investment*, and the weight, *****. This implies that only methods fulfilling the requirements of the attribute (indicated by the usability score, **X**) can be chosen. In this case both MBITI and CSF are useful, whereas the methods, NPV and IE, are not able to fulfil the necessary requirement. This is indicated by a + or - in the bottom row of *Table 53*.

The second parameter, *IT evaluation criteria*, was assigned three attributes, *Financial*, *Strategic* and *Effectiveness of use*, and a weight of **2**. The *Subtotal*s of the method's usability scores, (**X**, **(X)** and **No Cross**), are calculated by multiplying each attribute's usability score and the respective weight, and thereafter summarising these.

In the example the *Subtotal* of IE's usability score, **X**, is calculated by multiplying the weight, 2, with the number of, X (which in this case is 2), which in total gives 4 (see *Table 53*). Using the same approach it is seen that MBITI is given a, **+**, in the usability score, *****.

This approach is repeated for all the usability scores and all the methods. The calculated *Subtotal*s are input to the bottom part of the table.

*Table 53. Extract of paper-based version – Combining attributes and weights*

| Selected attribute | | Ref. | NPV | MBITI | IE | CSF | Weight |
|---|---|---|---|---|---|---|---|
| Multiple | **Purpose of IT Evaluation** | | | | | | |
| | Identify the best IT investment | 1.3.1 | X | (X) | X | (X) | * |
| | Evaluate impact from IT investment | | X | X | X | | |
| X | Manage IT investment | | | X | (X) | X | |
| | Increase knowledge and skill | | X | X | X | X | |
| Multiple | **IT Evaluation Criteria** | | | | | | |
| X | Financial | 1.3.2 | X | X | X | | 2 |
| X | Strategic | | | X | X | | |
| | Competitive | | | | X | | |
| X | Effectiveness of use | | | X | | | |
| | Quality improvements | | | | | | |
| | Requirements | | | | | X | |
| | End-user satisfaction | | | | | (X) | |
| | External satisfaction | | | | | | |
| | Technology | | | | X | | |
| | Risk | | | X | X | | |
| ***Subtotal*** | | | | | | | |
| | X | | 2 | 6 | 4 | 0 | |
| | (X) | | 0 | 0 | 0 | 0 | |
| | No Cross | | 4 | 0 | 2 | 6 | |
| | * | | - | + | - | + | |

Controlling the calculations is done by summing the three first rows in *Subtotal*. The sum of each methods' usability scores is calculated as 6, which is also the sum of the weights. This control should be completed in order to ensure that the *Subtotal*s are calculated correctly.

### 11.4.5 Identifying the best matching method

The fourth and last step is identifying the best matching method. *Table 54* shows an example of an output table where the derived data from *Table 53* (the *Subtotal*) is input. Another set of data (see the area called, *Company*, in the *Table 54*) has been input in order to be able to show how the total is calculated.

The bottom part of *Table 54*, called *Total*, is derived by summing each method's usability scores for the three groups of parameters.

Taking, for example, NPV the *Total* of the usability score, **X**, is calculated by summing the *Subtotal*s of **X**, in the three groups of parameters. In practice this means that the usability score, X, in, *Company*, (which is equal to 1) is added with the usability score, X, in *IT evaluation*, (which is equal to 2). In total this gives 3. This is also illustrated in *Table 54*.

This is done for all the methods' usability scores except ***** (as previously described).

*Table 54. Extract of paper-based version – Identifying the best matching method*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **Company** | | | | |
| X | 1 | 4 | 3 | 2 |
| (X) | 0 | 3 | 1 | 2 |
| No Cross | 6 | 0 | 3 | 3 |
| * | + | + | + | + |
| **IT Evaluation** | | | | |
| X | 2 | 6 | 4 | 0 |
| (X) | 0 | 0 | 0 | 0 |
| No Cross | 4 | 0 | 2 | 6 |
| * | - | + | - | + |
| **IT Investment** | | | | |
| X | | | | |
| (X) | | | | |
| No Cross | | | | |
| * | | | | |
| ***Total*** | | | | |
| X | 3 | 10 | 7 | 2 |
| (X) | 0 | 3 | 1 | 2 |
| No Cross | 10 | 0 | 5 | 9 |
| * | - | + | - | + |

Another control should be completed at this stage. By summing the *Total*s of the usability scores, **X**, **(X)** and **No Cross**, for each method, the sum should be equal. If not, the calculations have gone wrong.

The choice of IT evaluation method is, in the example, without doubt MBITI because it fulfils the necessary requirement and has the highest usability scores (both with regards to **X** and **(X)**). NPV and IE are excluded because they are not fulfilling the necessary attribute (which has been assigned the weight: *). The last available method, CSF, is considered useful as it fulfils the necessary attribute, but the usability scores are lower than MBITI's implying that MBITI matches the requirements better than CSF.

## *11.5 Important factors in using the framework*

In the following a series of important factors that are important for the usage of the framework are commented on.

The method receiving the highest usability scores in the framework should not be taken as the ultimate method. One of the main objectives of the framework is for the user to achieve a deeper understanding of contingencies involved in deciding which IT evaluation method to choose. Examples of such uncertainties are many, like changes in IT system requirements, change of IT evaluation domain, increased competition, etc. The IT evaluation, as characterised by the selected attributes, might, because of these contingencies, quickly change and the user needs to be aware of this dynamic.

As indicated in the previous paragraph the choice of method based on the output from the framework should not be seen as the ultimate choice. In the usage of framework the user will be confronted by a series of questions (especially in the process of selecting the parameters' attribute(s)), which might be difficult to answer. In the search for the best matching method, it is therefore important to realise that the process of completing the framework is equally important to the identification of the best matching method.

One of the most important factors for the usage of the framework is the user's understanding of the assumptions. It requires a detailed insight into the actual IT evaluation, both with regard to the nature of the IT investment, and also to the context. Without a detailed understanding of these, the uncertainties in the choice of attributes and weights will greatly affect the choice of method. If this is not true the chosen method might not be the best in the actual IT evaluation. The user of the framework (who may not necessarily be the one that is completing the IT evaluation) must therefore have a good understanding of both the IT investment and the nature of the context.

Even though the usage of the framework does not explicitly require any knowledge of the four methods, it is considered necessary that the user is aware of the differences in the methods and the assumptions made in each. This is especially important if the user is also the one who is completing the method. This is primarily because the user needs to be able to critically analyse the output provided by the framework.

The contingencies in IT evaluations are unstable as changes happen as time goes by. The user must therefore be aware that the output from the framework is only a static picture reflecting the best choice of method in the actual IT evaluation. From time to time it is therefore necessary that the user rethink the choices made during the process of completing the framework. In case of changes in any of the attributes choices or the weights, the user has to complete the framework once again to identify whether the best matching method is still the same.

The perception of the actual IT evaluation varies depending on the person, and this might imply changes in the output of the framework. Two approaches can be used to solve this problem. First, the user can choose to claim that the characteristics of the IT evaluation are, as he/she understands them. This means that the user's perception of the IT evaluation will be the ruling one. Another approach could be to complete the framework using another person's perception of the characteristics of the IT evaluation, to identify the differences in the framework's output. These could then be used to identify the best compromise in the choice of method. The second approach might be considered as inappropriate, as it is time consuming when using the paper-based version of the framework. This is not the case when using the software-based version.

## 11.6 Description of possible output

In this section a description of the possible output from using the framework is made. The descriptions will not be based on practical examples but, by theoretically analysing the possible outcomes, and therefore only significant outcomes are described (as opposed to describing all the possible output).

Four different types are relevant when describing the output of the framework:

- No usable methods are identified
- Only one method is identified as useful, but its usability scores are low
- Two or more methods are score equally
- One method is identified as the best

Other possible outcomes can be mentioned (e.g. two equally scoring methods are identified but the others are not usable), but they are not considered as being significantly different, as they are combinations of the four already mentioned output.

### 11.6.1 No usable methods are identified

The first outcome is that none of the four methods fulfils the necessary requirement. This outcome is the worst of the four as the user has not been able to identify a useful method that was the objective of completing the framework. The effort should, however, not be considered as completely wasted because of the increased knowledge gained through using the framework.

The primary conclusion that can be derived is that none of the four methods fulfils the necessary requirements, but other methods, not included in the framework, might be able to fulfil them. The search for a method should therefore be continued among the other available methods (a list of available methods can be found in chapter 2).

### 11.6.2 One method is identified as useful, but its usability scores are low

The second outcome described is that only one method is useful and its scores are considered as low compared to the *Total* of the usability score, **No Cross**. This indicates that the method is fulfilling all the necessary requirements but is not matching the requirements very well, whereas the others have failed to fulfil the necessary requirements.

Two problematic aspects can be derived from this outcome. First, it is a problem that only one method is useful, as it gives no alternative choices. This might mean that other methods, not included in the framework, should be examined for their usefulness. Second, the low score of the method indicates that it is not fulfilling the requirements very well and might, because of this, be considered as less useful. Whether this is special for this method or not, can be examined by comparing the score of the usable method with the other methods' score (which can be seen in the output table in the paper-based version), and thereafter it can be seen whether the score is low or high compared to the others. In the case of a low score compared to the other methods, the user should reconsider the choices of attributes and/or weights, or examine others methods than the four.

### 11.6.3 Two or more methods score equally

The third outcome is that two or more methods are scoring equally high. This outcome is positive as several methods are potentially useful and the choice of method can be made freely. It is however believed that this output rarely occurs.

The conclusion based on such an output is that the two methods are equally usable and therefore either of them can be chosen. There is, in some cases, an opportunity to increase the requirements for the methods by, for example, selecting several attributes in those parameters that allow a selection of multiple attributes. This should, however, only be done if the user thinks there is room for a more advanced method.

### 11.6.4 One method is identified as the best

The last outcome is the most straightforward as one method has been identified as best matching method. This means that a method has only been identified as the best matching of the four methods included in the framework.

No problems can directly be related to this outcome, but it cannot be used to conclude that this is the best matching method considered all the available methods (this aspect is also relevant for some of the other possible output). If the user is not confident that this method is good enough, then other methods should be examined.

## 11.7 Summary

During this chapter two versions, illustrating how the framework can be implemented, have been presented, paper-based and software-based. The description of how to use the framework is primarily based on the paper version.

Valid for both is that four steps are needed to identify the best matching IT evaluation method.

- Select the best matching attribute(s) in the parameters
- Select the parameters' weight
- Combine the parameters' attributes and the weights
- Identify the best matching method

A number of possible types of output have been described.

- No usable methods are identified
- Only one method is identified as useful, but its usability scores are low
- Two or more methods are score equally
- One method is identified as the best

# Chapter 12: Testing the framework

This chapter describes how the framework is tested with regard to the validity of the output produced. The primary objective of testing the framework is not to prove its validity in all possible IT evaluations, because this would indeed be a time consuming task, but to check that the output from the framework are consistent with the experience of the case studies.

In the first part of this chapter the framework is used on the five case studies (see chapter 5). The output from using the framework are commented on and compared with the experiences from the case studies (see chapter 7).

The second part of the chapter is a presentation of the experience gained by demonstrating the framework to some of the primary contact persons in the case studies (mainly IT managers). The experiences from the interviews are used for three purposes. First, some suggestions for improvement of the framework were discussed on the basis of a demonstration of the framework. Second, the interviewees commented on the output from the framework by comparing them with their own experience from the case study. Third, by examining how the interviewees perceive the usefulness and benefits of the framework.

## *12.1 Methodology for testing the framework*

After the development of the paper-based version it has been tested on the five case studies. The methodology for the test of the framework is as follows.

First, the framework was completed on the basis of the data and experience gained through the completion of the case studies, by completing the four steps as described in chapter 11.

- **Step 1: Select the best matching attribute(s) in the parameters**
  The selecting of the appropriated parameters' attribute(s) was done on the basis of the description in chapter 9, where the case studies are described in relation to each of the possible attributes.
- **Step 2: Select the parameters' weight**
  In the completion of the second step of the framework, the weight of each parameter is estimated on the basis of the experience gained in the five case studies.
- **Step 3: Combine the parameters' attributes and the weights**
  The third step was completed on the basis of the input data already identified in the two previous steps. The output table for each of the case studies was, as a part of this step, generated.
- **Step 4: Identifying the best matching method**
  The fourth step was completed by identifying the best matching method (if possible) which thereby is also the method that in real life should be chosen for use in the IT evaluation.

Second, the output from the framework were then compared with the experience of the methods' usability in each of the case studies, as described in chapter 7. The differences and similarities between the output from the framework, and the experience from completing the case studies, are then discussed. Such a comparison is not meant to prove the validity of the framework (as this would be a bad approach), but rather to identify whether the framework is in harmony with the case studies from which it is developed.

## 12.2 The five case studies

The five case studies described in chapter 5 are, in this section, being tested with regard to which IT evaluation method should be chosen according to the framework. The approach used in the completion of the framework has been described in the previous section.

The three tables and the output table from testing the framework on the five case studies can be seen in the following Appendices B10, C12, D6, E11 and F11.

*Table 55. Summary of the framework's output on the five case studies*

| | Rambøll | Cowi | NIRAS | H&S | TJAS |
|---|---|---|---|---|---|
| NPV | 29/4/6/+ | 17/5/25/- | 27/5/11/+ | 27/5/12/+ | 18/5/9/+ |
| MBITI | 28/7/4/+ | 37/8/2/+ | 19/11/13/+ | 25/14/5/+ | 23/3/6/+ |
| IE | 26/7/6/+ | 38/2/7/- | 22/5/16/+ | 30/7/7/+ | 19/5/8/+ |
| CSF | 17/4/18/+ | 17/12/18/+ | 30/4/9/+ | 19/9/16/+ | 22/5/5/+ |

The grey cells in *Table 55* highlights the best matching IT evaluation method derived from the output from the paper-based version. The numbers and symbols in the cells are the different *Total*s of the usability scores for **X**, **(X)**, **No Cross** and *****.

When identifying the best matching method one case study in particular needs to be explained. In the case study with Rambøll it can be seen that NPV is receiving 29 optimal matches and 4 usable matches whereas MBITI gets respectively 28 and 7. The best matching method is, despite a higher usability score **X**, regarded as MBITI, because it has three more usable matches, which is regarded as better than the difference of one useful match. Also the case study with Cowi needs to be explained, as IE receives a higher usability score, **X**, than MBITI. The usability score, **(X)**, is, however, significantly higher for MBITI than IE and, most importantly, IE does not fulfil the necessary requirement.

As can be seen in *Table 55* MBITI is the best matching method in three out five case studies if both **X** and **(X)** is taken into consideration, whereas IE and CSF are each the best matching method in one case study. NPV is not identified as the best matching method in any of the case studies but, if the table is examined in greater detail, then it is revealed that, in three of the case studies, it is the second best matching method. In general it can be concluded that three out of four methods have been identified as the best matching method in at least one of the case studies.

### 12.2.1 Rambøll

The *Subtotal*s and the *Total* are shown in the output table from the framework and can be seen in *Table 56* (see also Appendix B10). Greying the method's name and *Total* of the usability scores indicates the best matching method.

*Table 56. Output table from framework in Rambøll*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **Company** | | | | |
| X | 6 | 7 | 10 | 7 |
| (X) | 2 | 5 | 0 | 4 |
| No Cross | 4 | 0 | 2 | 1 |
| * | - | - | - | - |
| **IT Evaluation** | | | | |
| X | 16 | 12 | 12 | 7 |
| (X) | 0 | 2 | 4 | 0 |
| No Cross | 2 | 4 | 2 | 11 |
| * | - | - | - | - |
| **IT Investment** | | | | |
| X | 7 | 9 | 4 | 3 |
| (X) | 2 | 0 | 3 | 0 |
| No Cross | 0 | 0 | 2 | 6 |
| * | - | - | - | - |
| ***Total*** | | | | |
| X | 29 | 28 | 26 | 17 |
| (X) | 4 | 7 | 7 | 4 |
| No Cross | 6 | 4 | 6 | 18 |
| * | + | + | + | + |

MBITI and NPV are almost equal in their scores from the framework, which is the reason for the more in-depth analysis of the scores in pursuit of the identification of the best matching method as commented on in the above paragraph. As already mentioned this resulted in MBITI being identified as the best matching method of the four available, even though NPV has a better usability score, **X**.

The third best matching method is found to be IE, which also has received reasonable usability scores compared to both MBITI and NPV. The last method is CSF which has a high *Total* of the usability score, **No Cross**, implying that the method does not match many of the requirements of the IT evaluation.

The "picture" described in the paragraphs above is very close to the experience gained when completing the four methods in the case study. MBITI was at that time recognised as the best method for various reasons described in chapter 7. NPV was recognised as the second best matching method, and would have been the best if the original purpose of the IT evaluation were unchanged. This is closely related to the output from the framework where NPV is ranked as the second best method.

Overall the consistency of the framework's output and the experience from the case study are therefore considered good.

### 12.2.2 Cowi

Testing the framework on the case study with Cowi provided output that clearly identify MBITI as the best matching method. Examining the output shown in *Table 57* (see also Appendix C12) reveal that the requirements identified from the group of parameters called, *IT evaluation*, have the greatest influence on the choice of method.

*Table 57. Output table from framework in Cowi*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **Company** | | | | |
| X | 6 | 9 | 11 | 6 |
| (X) | 2 | 4 | 2 | 5 |
| No Cross | 5 | 0 | 0 | 2 |
| * | + | + | + | + |
| **IT Evaluation** | | | | |
| X | 10 | 19 | 16 | 5 |
| (X) | 0 | 0 | 0 | 0 |
| No Cross | 11 | 2 | 5 | 16 |
| * | - | + | - | + |
| **IT Investment** | | | | |
| X | 1 | 9 | 11 | 6 |
| (X) | 3 | 4 | 0 | 7 |
| No Cross | 9 | 0 | 2 | 0 |
| * | + | + | + | + |
| **Total** | | | | |
| X | 17 | 37 | 38 | 17 |
| (X) | 5 | 8 | 2 | 12 |
| No Cross | 25 | 2 | 7 | 18 |
| * | - | + | - | + |

The second best matching method is IE, which almost has a *Total* of usability scores as high as MBITI. It is identified as the method that fulfils most of the requirements from the group of parameters called, *IT investments*, except for one important (and necessary) attribute in, *Purpose of IT evaluation* (see the later paragraph).

The two methods left are NPV and CSF, which both poorly match the requirements compared to MBITI and IE. These two methods are in two out of three groups having a low *Subtotal* of usability scores. Just as is the case with IE, NPV is greatly influenced by one attribute as described in the next paragraph.

One aspect, significantly affecting the framework's output, is that the parameter, *Purpose of IT evaluation*, which was given the weight, *****, as this was the primary argument for completing the IT evaluation (see eventually chapter 5). This results in both NPV and IE being considered as not useful because they do not fulfil the necessary requirement.

Comparing the framework's output with the experiences gained in the case study there is found to be a good relationship. MBITI was also recognised as the best of the four methods, primarily because it supported the company's objective of developing a measurement plan.

### 12.2.3 NIRAS

In the case study with NIRAS the framework identified CSF as the best matching method closely followed by NPV (see Appendix D6). Viewing the *Subtotal*s of the CSF's usability scores reveals that the method has high usability scores in both, *Company* and *IT evaluation*, whereas in, *IT investment*, it is NPV that is the best matching method.

Especially interesting is the *Subtotal* of usability scores for CSF in, *IT investment*, because it is only the third best method in this group of parameters, and this indicates that the requirements derived from these parameters are not fulfilled by the method.

*Table 58. Output table from framework in NIRAS*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **Company** | | | | |
| X | 7 | 5 | 6 | 9 |
| (X) | 1 | 6 | 0 | 2 |
| No Cross | 3 | 0 | 5 | 0 |
| * | + | + | + | + |
| **IT Evaluation** | | | | |
| X | 10 | 8 | 12 | 12 |
| (X) | 4 | 2 | 0 | 2 |
| No Cross | 7 | 11 | 9 | 7 |
| * | + | + | + | + |
| **IT Investment** | | | | |
| X | 10 | 6 | 4 | 9 |
| (X) | 0 | 3 | 5 | 0 |
| No Cross | 1 | 2 | 2 | 1 |
| * | + | + | + | + |
| ***Total*** | | | | |
| X | 27 | 19 | 22 | 30 |
| (X) | 5 | 11 | 5 | 4 |
| No Cross | 11 | 13 | 16 | 9 |
| * | + | + | + | + |

The two other methods, MBITI and IE, are in general poorly matching the requirements in all three groups of parameters. One exception is, IE, which receives an equal usability score of, **X**, to CSF in, *IT evaluation*. This means that both IE and CSF fulfil some of the requirements with regard to some of the parameters in *Company*.

Comparing the framework's output with the experience gained in the completion of CSF in the case study (this was the only method out of the four that was completed in the case study), there is a certain match. CSF was also identified as useful in the case study, primarily because it enables the company to achieve a better understanding of the actual requirements of the IT investments. The conclusions are, however, severely constrained by only one method actually being completed.

### 12.2.4 Højgaard & Schultz

Completing the four steps in the framework resulted in the following output table as seen in *Table 59* (see also Appendix E11).

*Table 59. Output table from framework in Højgaard & Schultz*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **Company** | | | | |
| X | 5 | 5 | 8 | 6 |
| (X) | 3 | 6 | 0 | 4 |
| No Cross | 3 | 0 | 3 | 1 |
| * | + | + | + | + |
| **IT Evaluation** | | | | |
| X | 16 | 12 | 16 | 6 |
| (X) | 0 | 5 | 4 | 3 |
| No Cross | 6 | 5 | 2 | 13 |
| * | + | + | + | + |
| **IT Investment** | | | | |
| X | 6 | 8 | 6 | 7 |
| (X) | 2 | 3 | 3 | 2 |
| No Cross | 3 | 0 | 2 | 2 |
| * | + | + | + | + |
| ***Total*** | | | | |
| X | 27 | 25 | 30 | 19 |
| (X) | 5 | 14 | 7 | 9 |
| No Cross | 12 | 5 | 7 | 16 |
| * | + | + | + | + |

As seen in *Table 59* the best matching method in the case study with H&S is IE. Two groups of parameters influence this output most, *Company* and *IT evaluation*, in which IE is the best matching method. The requirements from, *IT evaluation*, are almost fulfilled for every attribute selected. In, *IT investment*, IE and NPV have the lowest *Subtotal* of usability scores.

The second best matching method is NPV, which almost has the same *Total* of usability scores as IE. In, *Company*, there is a difference primarily because IE is fulfilling the requirements derived from the basic company characteristics like Type of company, better than NPV.

MBITI is ranked as the third best method and CSF as the last. These two methods are in two out of three groups having lower *Subtotal*s of usability scores than IE. CSF received a significantly lower *Total* of usability scores than the three other methods, primarily because the method is not fulfilling many of the requirements in, *IT evaluation*.

In the use of the methods in the case study, IE was identified as the most useful method (a more detailed explanation of this is described in chapter 7). The primary reason behind this choice is the method's ability to compare different IT investments. This is also reflected in the framework's output as seen in *Table 59*.

Overall it is concluded that the framework is providing output that also reflect the experience gained when the four methods were completed.

### 12.2.5 Troels Jørgensen A/S

In the last case study with TJAS, the framework identifies MBITI as the best matching method as seen in *Table 60* (see also Appendix F11). MBITI matches their requirements in both, *Company* and *IT investment* reasonably well. The third group of parameters, *IT evaluation*, does not result in high *Total*s of usability scores but it is not much lower than the other methods.

*Table 60. Output table from framework in Troels Jørgensen A/S*

| | NPV | MBITI | IE | CSF |
|---|---|---|---|---|
| **Company** | | | | |
| X | 5 | 8 | 6 | 7 |
| (X) | 3 | 1 | 1 | 2 |
| No Cross | 3 | 2 | 4 | 2 |
| * | + | + | + | + |
| **IT Evaluation** | | | | |
| X | 8 | 7 | 7 | 8 |
| (X) | 2 | 2 | 2 | 0 |
| No Cross | 1 | 2 | 2 | 3 |
| * | + | + | + | + |
| **IT Investment** | | | | |
| X | 5 | 8 | 6 | 7 |
| (X) | 0 | 0 | 2 | 3 |
| No Cross | 5 | 2 | 2 | 0 |
| * | + | + | + | + |
| ***Total*** | | | | |
| X | 18 | 23 | 19 | 22 |
| (X) | 5 | 3 | 5 | 5 |
| No Cross | 9 | 6 | 8 | 5 |
| * | + | + | + | + |

The second best matching method is CSF which almost has the same *Total* of usability scores as MBITI. The reason for this is not that the method fulfils the same requirements as MBITI but, on the contrary, CSF fulfils those requirements not fulfilled by MBITI.

The last two methods, NPV and IE, are both having low *Total*s of usability scores primarily because they are not fulfilling the requirements in neither *Company* nor *IT investment*. NPV especially has a low *Subtotal* of usability scores in, *IT investment*, because it only fulfils the requirements from two attributes (see Appendix F11).

The usability of MBITI in the case study was clearly found to be the best compared to the other methods. Using MBITI gave the IT evaluation champions a better understanding of the IT investment's impact on the company, which they did not have beforehand. It is therefore concluded that the framework's output reflect the experience gained in the case study.

### 12.2.6 Validity of the framework's output

In the previous section the output from the framework were compared to the experience gained when the four methods were completed in each of the case studies. The comparison identified a good match between the framework's output and the case study experience in all five case studies. One case study is, however, severely constrained by the fact that only one method was completed

and cannot therefore be used to conclude that the framework's output reflected the actual ranking of the methods' usability.

It is concluded that the framework in at least four of the case studies reflects the usability experienced in the methods.

## 12.3 Demonstration of framework to four IT managers

After the development of the framework was finished, it (both the paper-based and the software-based versions) was demonstrated to a few of the key persons that were involved in the case studies.

### 12.3.1 Approach for demonstration of framework

The demonstration had three purposes. First, to get feedback on the structure and usage of the framework, second, to obtain some comments on the output from the framework using the case study they were a part of, and third, to get some comments on the usefulness of the framework for their own work.

The persons invited to the demonstration of the framework were from the key persons from the five case studies. This was done primarily because they are the only persons working in the construction industry that can be expected to know the nature of the four methods (as they have completed them in the case studies). The knowledge of the four methods is considered necessary as this ensures the feedback on whether the usability of the framework is based on a correct understanding. Also the second aspect, mentioned above, is that it is not possible to complete without the persons who were involved in the case studies.

The approach used in the demonstration of the framework was very straightforward, as it followed the sequence of the purposes described above. The first step was to demonstrate the framework by using the characteristics of the case study they were involved in. In the demonstration it was primarily the software-based version that was presented, but the paper-based version was also presented. After the demonstration the interviewee was first asked about the structure and usage of the framework that could or should be improved. Second the interviewee was asked about the framework's output compared to their own experience in the case study and last, they were asked about the usefulness of the framework.

### 12.3.2 Comments on the framework

Many useful comments were obtained from the interviewees and some of them have been implemented while others were considered as exceeding the scope of the problem statement as described in chapter 1.
The suggestions for improvement were the following (primarily focused on the software-based version):

- Help functions
- Explanations of the IT evaluation methods
- More accurate definition of the cost of the IT evaluation methods (for example % of IT investment cost)
- Combining the selection of the parameters' attribute(s) and its weighting on one screen
- Using alphanumerical attributes when assigning the weights
- More advanced weighting of the parameters (for example weighting of the three groups of parameters)

- Identification of groups of methods (instead of just identifying a specific IT evaluation method, could also identify the group of methods that is useful)

Those suggestions and comments that were considered as relevant were, if possible, implemented if they did not require too many resources. For example the weights in the software-based version were changed from numerical to text. This enables a more easily interpretable selection of the weights assigned to each parameter.

A few aspects in the software-based version were highlighted as beneficial. All four interviewees mentioned the framework's ability to simulate "what-if" scenarios as very good, because it allows the user to reassess the impact of changing the attributes and/or weights, on the methods' usability scores. This ability is not available in the same way in the paper-based version, which makes this version less beneficial.

The interviewees from Cowi and H&S also expressed the view that the user's opportunity for interacting with the software-based framework is beneficial because it allows an easier completion of the four steps as described in chapter 11. The user is responding to simple requests that give a good overview of the process and the progress in using the framework.

The interviewee from H&S mentioned that the software-based version was significantly easier to complete than the paper-based version. The paper-based version is time consuming because the usability scores are calculated manually, whereas the software-based version calculates these automatically.

### 12.3.3 Output of framework

In general the four interviewees considered the output of the framework as reflecting their experience of the IT evaluations. The comments on the framework's output are described in the following.

The interviewee from Rambøll did, at the time of the case study, prefer the method, IE. This is opposed to the framework, which identifies that MBITI was the best matching method. The difference in the interviewee's perception of which method is the best and the framework's output, is partly because the interviewee experienced IE as easier to complete than MBITI. This is, however, not true as IE requires almost the same economic data as MBITI and, in addition to that, many other types of data (marking of factors, company weightings etc.), which in total makes IE more demanding than MBITI because it, to a greater extent, involves other stakeholders.

The interviewee from H&S said that MBITI was good because it gave a good insight into the impact from the IT investment, but found, in the actual IT evaluation, that IE was the best as it gave a good overview of the IT investments which could be used to compare them. The framework also identified, in the case study, that IE was the best matching method and was therefore in line with the interviewee's own experience.

The two interviewees from Cowi said that the framework's output were in a good agreement with their own experience of the completion of the four IT evaluation methods.

### 12.3.4 Usefulness of the framework

All four of the interviewees said that the framework is useful when choosing an IT evaluation method.

Especially the interviewee from H&S considered the framework as a potential improvement of the company's IT evaluation practice, because it is a tool that enables the company to penetrate the massive barriers in IT evaluations. IT evaluations are often not completed using a formal procedures simply because the company does not know where to begin and end. In this perspective the framework is a tool the company can use as a start in completing more formal IT evaluations.

The interviewees from Rambøll and H&S both mentioned that there is long way from the current IT evaluation practice in the construction industry to the usage of a framework that identifies the best matching IT evaluation method. In other words they recognise that the framework alone is not enough to improve the IT evaluation practice in the company, but may be a step on the way.

The interviewee from H&S stated that in the rare cases, where an IT evaluation was completed, the company hired an external consultant. He was certain that the framework could be the opportunity that starts changing this practice.

The interviewees from Cowi thought that the software-based version was very useful as they are usually almost forced to hire external consultants whenever they want to assess an IT investment's value. The result of this has not always been satisfactory, which among other things, is often caused by a lack knowledge of the characteristics of the construction industry by the external consultants.

## 12.4 Summary

This chapter has described the comparison of the framework's output with the experience gained through use of the four IT evaluation methods in the case studies.

The comparison revealed that the choice of IT evaluation method, as identified by the framework's output and the experiences gained in the case studies, are consistent in at least four out of five case studies. The fifth case study cannot be used to validate the framework's output as only one out of four IT evaluation methods was completed. Although the comparison cannot be regarded as proof of the validity of the framework's output in other real-life IT evaluations than those completed, it can be concluded that the framework has, at least, not failed to provide consistent output.

The framework's output was shown to a number of the key persons at the case study companies in order to identify whether it was consistent with their experience. Three out of four recognised the validity of the framework's output, whereas the fourth preferred another method than the one identified by the framework. This difference is, however, based on a wrong perception of the IT evaluation methods.

All the key persons interviewed confirmed the usefulness of the framework as a means of improving a company's IT evaluation practice.

# Chapter 13: Conclusion

The final chapter primarily describes the validation of the two hypotheses and the central research aim put forth in chapter 1.

In the first part of the chapter the two hypotheses are discussed and validated. The validation is done on the basis of the expectations that can be derived from the hypotheses compared with evidence identified in the previous chapters. The validation of the hypotheses will be valuable for further research in this field.

The second part of the chapter describes the validation of the research aims and questions. These have been used as a guideline throughout the chapters in the dissertation and the answers to the research questions in chapter 1 are therefore summarised in this chapter.

The last part of the chapter describes the possibilities for further research in this field. Among other thing the possibility of commercial and research-based interests are discussed. The topics that are considered as related to this thesis, but which have not been a part of it, are mentioned and discussed. It is hoped that interested parties, both commercial and research, will exploit these possibilities further.

## *13.1 Validation of hypotheses*

Two hypotheses put forth in chapter 1 are claiming that (a) there is not one best IT evaluation method and (b) a framework that enables a user to identify the best matching IT evaluation method can improve a company's IT evaluation practice.

For each of the two hypotheses a number of statements were derived which in the following are discussed on the basis of the description of IT evaluation methods (chapter 2 and 3), the questionnaire survey (chapter 4), the case studies completed (chapter 5 to 7) and the framework (chapter 8 to 12).

### 13.1.1 Hypothesis 1

The first hypothesis, as described in chapter 1, is as follows:

**There is not one best IT evaluation method for all cases.**

Two statements are derived from the hypothesis in order to test its validity. The first derived statement predicts the following:

**The available IT evaluation methods are fulfilling different requirements**

An extensive list of available IT evaluation methods has been generated where, in total, 82 methods are listed. All these methods can be described by a number of characteristics so it is possible to identify their similarities and differences. A number of representative methods were selected and tested in a series of case studies and, through these, it was revealed that the methods' characteristics fulfil different requirements. The above statement is therefore valid as the IT evaluation methods fulfil different requirements depending on their characteristics.

The second statement derived from hypothesis one is as follows.

**Evaluations of different IT investments require different IT evaluation methods**

In the five case studies, which were unique and independent from each other, four radically different methods were tried out. In the case studies it was revealed that the methods were not found to be equally useful or that one method was better than all the others. Based on this evidence it is concluded that the above statement is valid.

Considering the two statements above, it can be derived that it is not possible to identify one method that is the best in all possible IT evaluations. On this basis it is therefore concluded that **the first hypothesis is valid**.

### 13.1.2 Hypothesis 2

The second hypothesis described in chapter 1 is, in some sense, related to the first hypothesis as, if this is not valid, it would not make sense developing a framework which identifies the best matching method. The hypothesis is as follows:

**The use of the framework for the identification of the best matching IT evaluation method for an IT investment improves a company's IT evaluation practice.**

Four statements are essential in proving the second hypothesis. All four statements are related to what is understood by improving a company's IT evaluation practice.

Using the framework results in a company…

**…having a greater awareness of available IT evaluation methods**

The tendency identified in a large number of companies from the construction industry (see eventually chapter 4) is that the usage of formal IT evaluation procedures is very small and therefore so is the usage of IT evaluation methods, that use formal IT evaluation procedures, also very small. This characteristic was also identified in the five case studies (see chapter 5). Using four IT evaluation methods (that are characterised as using formal IT evaluation procedures) in the case studies was found to increase the five case study companies' awareness of available methods. As the framework is based on the same four IT evaluation methods as used in the case studies, it is concluded that companies' awareness of available IT evaluation methods is increased. The statement is therefore valid.

**…using more formal IT evaluation procedures than today**

There are indications stating that companies from the construction industry primarily use informal IT evaluation procedures even though many formal methods exist. Using the framework will help a company with using a more formal IT evaluation procedure as the framework only includes methods, that are characterised as using formal IT evaluation procedures. The advantage of using more formal IT evaluation procedures was also found in the case studies, where the companies previously used informal procedures when evaluating their investments, when the four methods in the framework were completed. The statement is therefore valid.

**…considering more parameters when choosing an IT evaluation method**

When a company is using the framework it is forced to consider the requirements that have an influence on the choice of IT evaluation method and it is thereby possible to identify a better matching method. Without the framework the choice of IT evaluation method is typically guided by less rational criteria (which also increase the danger of possible political influences), resulting in the

usage of very informal IT evaluation procedures as identified in the questionnaire survey. Based on this it is concluded that the statement is valid.

**…being able to choose the best matching IT evaluation method**

The framework is based on a description of the parameters that have been identified as having an influence on the choice of method. When the company uses the framework in an IT evaluation, the characteristics of the IT evaluation are being matched with four different methods and ultimately the best matching method can be identified. It is therefore concluded that a company can, by using the framework, identify the best matching method in an IT evaluation and therefore this statement is valid.

As all four statements are valid it is concluded that the framework can indeed improve a company's IT evaluation practice as claimed in hypothesis two. It is therefore concluded that **hypothesis two is valid**.

## 13.2 Validation of research questions and aim

In chapter 1 five research questions were listed in order to identify topics that need to be examined in the thesis. Each of these is discussed below.

**How can companies evaluate their IT investments by using IT evaluation methods?**

The first thing to be commented on is that there is no absolutely right or wrong method for IT evaluations. The important point is that some methods are, in some IT evaluations, better than in others. In chapter two 82 IT evaluation methods were listed. They are all, at least partly, describing how an IT evaluation should or can be completed. Four of the identified methods were selected in chapter 3 and described with regard to their characteristics and how they are done, which are examples of how companies can complete IT evaluations.

**How are companies today evaluating their IT investments in the Danish construction industry?**

In chapter 4 it was revealed that surprisingly many companies from the Danish construction industry are not evaluating their IT investments at all. This is partly because the companies' strategic plans are unclear and many companies have no written IT strategy, which makes it more difficult to identify what to evaluate. Those companies that do IT evaluations are primarily using oral guidelines and subjective arguments when they evaluate. A high proportion of the companies evaluate their IT investments before they are approved whereas, in the later stages, the frequency of IT evaluation drops significantly. The most used IT evaluation criterion is not, as expected, the *Financial value* but the *Effectiveness of use,* which is odd considering that most of the IT investments are focused on increasing the efficiency and effectiveness of the company's business activities.

An interesting finding in chapter 4 is that almost 60% of the responding companies cannot document the effects gained through using IT, which is worrying considering the large amount of money invested in IT as seen in both the introduction and in chapter 4.

**What are the experiences and results of using IT evaluation methods in real-life IT evaluations?**

Four IT evaluation methods were selected and described in chapter 3. In chapter 5 and 6 these methods were used in a series of case studies in order to try out how the methods are used in real-

life IT evaluations. Five different IT investments, that are considered as relevant for companies in the construction industry, were evaluated in the case studies.

None of the IT evaluations was completed easily as it was found to be difficult to identify the costs and benefits of the IT investments and to estimate the economically measurable costs and benefits. Some of the methods were found to be difficult to complete because, either they were not describing how to use them, or because the data requirement was unrealistic.

In general the IT investments could not be justified if only the financial value is taken into consideration in the IT evaluations, as three out of four show a negative financial value. If non-measurable benefits are taken into consideration then a more positive "picture" is displayed, as the IT investments in general are given a moderate to high score.

**What are the influential parameters when choosing an IT evaluation method for the Danish construction industry?**

A number of parameters have been identified through the description of IT evaluation methods, the survey and the case studies. Some of the parameters were identified several times. In total 21 parameters were identified as having an influence on the choice of the IT evaluation method as illustrated in *Table 61*.

*Table 61. List of identified parameters*

| Company | IT evaluation | IT investment |
|---|---|---|
| Company type | Purpose of IT evaluation | Type of IT investment |
| Company size | IT evaluation criteria | Size of IT investment |
| Company position | Format of output | Purpose of IT investment |
| Business strategy | IT evaluation champion(s) | IT investment domain |
| Decision environment | User of IT evaluation | Stage of IT investment |
| Role of IT | Cost of IT evaluation | Importance of IT investment |
| IT maturity | Difficulty of IT evaluation | |
| IT evaluation practice | method | |

The different parameters can be categorised into three different groups; *Company*, *IT evaluation* and *IT investment*, as in *Table 61*. Each of the parameters is defined and a series of attributes are identified as relevant in chapter 9. The parameters' influence on the choice of method was examined in the case studies on the basis of the four methods used.

**How should a framework for choosing the best matching IT evaluation method be structured and used?**

This research question cannot be answered in a simple way and the reader needs to read especially chapter 11 in order to understand how the framework is structured and used. Two versions of the framework have been developed; paper-based and software based. The dissertation primarily describes the paper-based version in order to be able to highlight the details of the framework (which is less easily done with the software-based version).

The main structure of the framework (both paper-based and software-based) is divided up into three areas; the parameters and their attributes, weightings of parameters and the output table. The first area is mainly structured through the identified parameters (including the three identified groups of parameters) and their attributes. The second area is focused on each parameter's weight when compared to the others, which has been included in order to enable the user to prioritise between the

parameters. The third and last area is the output table, which gives the user an insight into the methods' scores, and from which the user can identify the best matching method.

Using the framework is the same for the two versions of the framework but the software-based one is more easily completed because more of the tedious calculations and controls are completed without user participation. Four steps need to be completed when using the framework; (a) select the parameters' attribute(s), (b) estimate the parameters' weight, (c) combine the selected attributes with the parameters' weights and (d) identify the best matching method.

The first three research questions primarily fill a gap in knowledge. This is needed in order to answer the central research aim in the thesis as stated in chapter 1. The last two research questions are more directly related to fulfilling the research aim.

**How should a company in the Danish construction industry choose the IT evaluation method to be used when evaluating their IT investments?**

The central research aim consists of two elements: the first is about which criteria a company needs to consider when choosing an IT evaluation method, and the second is focused on the process of selecting the IT evaluation method.

The first element is primarily answered in research question 4, where a series of parameters have been identified as influencing the choice of IT evaluation method, and the second element is answered in research question 5, where the usage of the framework is described.

In all it is concluded that the five research questions have been answered and that the central research aim is fulfilled.

## *13.3 Assumptions and limitations*

This section presents the assumptions and limitations made in the thesis in order to discuss the usefulness of the knowledge presented.

### 13.3.1 Assumptions

Three important assumptions have been made in order to complete the work in the thesis; (a) formal IT evaluation procedures are necessary, (b) a life-cycle approach is necessary and (c) The choice of method is context dependent. These are discussed in the following.

**Formal IT evaluation procedures are necessary**

The first assumption is that completing formal IT evaluation procedures is necessary for identifying the value of the company's IT investments. One possible alternative to this is that informal IT evaluations are used because the value cannot be objectively identified anyway, but this alternative is considered as even more problematic, because it means that IT evaluations can be more easily biased by political issues which might not be in the interests of the company. Without this assumption the work is less useful as there would be no need for a framework like the one developed in the thesis.

In the research field of IT evaluation there is a widespread understanding that it is necessary to complete formal IT evaluation procedures (Ballantine, Galliers, & Stray 1996; CICA & CIRIA 1995; Farbey, Land, & Targett 1993; Love & Irani 2001;Willcocks & Lester 1999). The assumption

is therefore regarded as realistic but will, if not true, have a significant influence on the usefulness of the work in the thesis.

**Life-cycle approach necessary**

The second assumption made is that a life-cycle view is needed when identifying the requirements of the IT evaluation method. Completing the five case studies supported the assumption, by identifying that the requirements for the choice of IT evaluation method in different stages of the IT investments' life-cycle, are changing.

In the development of new methodologies for completing IT evaluations and new methods, there is often an assumption stating that they should be used at certain stages of the IT investments' life-cycle (for example ex-ante and/or ex-post) (Construct IT 1998; Parker & Benson 1988; Wolstenholme, Henderson, & Gavine 1993)[17]. The assumption therefore considers the comments above as realistic.

**Choice of method is context dependent**

The third assumption made is that the context of the IT investment is influencing the choice of method. The assumption is apparently true and seems to be rationally correct, but the assumption has not yet been validated. Completing the five case studies also supported the assumption that several of the parameters identified are related to the context of the IT investment and not directly to the IT investment.

Most researchers argue that the context influences the IT evaluation and therefore also the choice of IT evaluation method (Farbey, Land, & Targett 1995a; G.Khalifa, Irani, & Baldwin 1999; Pedersen & Larsen 2000; Smithson & Hirschheim 1998). This assumption is therefore regarded as reflecting real-life IT evaluations.

### 13.3.2 Limitations

Four limitations affects the results of the thesis; (a) use of the framework is limited to companies from the construction industry, (b) a company's point of view, (c) limited number of methods included in the framework and (d) limited possibilities for testing the framework.

All the limitations have a significant influence on the methodology used and the findings of the thesis, which will be discussed in the following.

**Use of the framework limited to companies from the construction industry**

The first limitation was the focus on companies[18] from the construction industry and their needs for improving their IT evaluation practice. The limitation is primarily influencing the parameters' attributes as defined in the framework and, through that, the relationships between the attributes and the four methods are partly based on evidence from the case studies (which all are strongly related to the construction industry).

The limitation can be considered both as a strength and weakness. The positive aspect of the limitation is that the framework more accurately reflects the needs and characteristics of these companies, whereas the weakness in the framework is that it might not be useful in any other context.

[17] See *Table 2* for a more complete list of current IT evaluation methods

[18] The number of different types of companies has also been limited but is not discussed separately as the limitation is not that different from this one

As the framework is designed, it is only relevant to the construction industry but it could be "translated" to other types of industries if the knowledge represented in the framework is amended so that it reflects other industries' needs and characteristics.

**Company's point of view**

The second limitation is that the framework is developed on the basis of a company's point of view, meaning that it is not considered as useful from an industry's point of view. This is despite the fact that there are IT evaluation methods developed especially for an industry's or a nation's point of view (an example of the former is (Lautanala, Enkovaara, Heikkonen, & Taiponen 1998) and the later (Porter 1990)). The limitation primarily influences the types of parameter identified and their attributes in the framework.

This limitation is argued to be necessary, as it would otherwise increase the complexity of the framework unnecessarily when considering the hypotheses and the central research aim. On top of that, it is also considered as more beneficial, as this is the level which has an urgent need for improving its IT evaluation practice.

**Limited number of methods included in framework**

During the literature review it quickly turned out to be necessary to limit the number of methods since 82 IT evaluation methods were identified and this list is not even complete. The framework is therefore limited to four IT evaluation methods because it simply was not possible to include all the identified methods (primarily because of a limitation in time).

The four IT evaluation methods included in the framework are chosen by using a list of criteria, as mentioned in chapter 3, whereof the most important criterion is that each of the selected methods represents a larger group of methods.

The limitation made is greatly influencing the framework and its usability, as the user might need to search for an appropriate method which is not included in framework. This results in the user not being able to identify a method that fulfils the requirements of the IT evaluation and thereby the usefulness of the framework is reduced. It is still argued that using the framework puts the user in a better position to choose an appropriate method.

**Limited possibilities for testing the framework**

The last limitation discussed is the limited possibility for testing the usefulness of the framework. Two aspects are relevant in this context.

First, ideally the framework should have been tested in another series of case studies where all four methods included in the framework were used on a real-life IT evaluations. This should be done in order to identify whether the framework identifies the best matching method in other case studies as well.

Second, the ideal validation of the second hypothesis would be to study a series of companies, that use the framework, and compare it with a study of a series of companies that are continuing their current IT evaluation practice (meaning that they are not using the framework) over a number of years. This would prove whether the usage of the framework indeed improves a company's IT evaluation practice.

Both aspects have, however, not been possible in this thesis primarily because of time limitations. This is considered as a significant limitation because it has great influence on the validation of the frameworks' output and the second hypothesis.

Overall the assumptions and limitations made in the thesis have a significant influence, but they also reveal that the framework might be beneficial beyond some of the limitations made.

## 13.4 Summarising the main points in the thesis

This thesis has in the previous chapters described research focusing on improving a company's IT evaluation practice. In the introduction the construction industry's IT evaluation practice was described as informal and ad hoc as IT investments are primarily evaluated by using informal IT evaluation procedures such as "acts of faith". This is an unsatisfactorily situation as the companies have very little knowledge of what *value for money* they receive from their IT investments, and because of the large number of available formal IT evaluation methods.

The current IT evaluation practice, as described in the introduction has, in chapter 4, been confirmed through a questionnaire survey where the majority of the responding companies use informal IT evaluation procedures.

Ideally companies should be able to evaluate their IT investments by the use of more formal IT evaluation procedures, and therefore a need for some guidance on how to choose between the available IT evaluation methods was identified.

To solve this problem the thesis describes a framework that enables companies from the construction industry to choose an IT evaluation method that matches the requirements of the IT evaluation. The framework consists of 21 parameters, each with a number of different attributes, that can be selected so they describe the actual characteristics of the IT evaluation. The parameters are divided into three groups each representing a relation to the IT investment and/or its context. By weighting the parameters relative importance, the framework provides an output that identifies the best matching IT evaluation method. Two versions of the framework have been developed and presented in the thesis; a paper-based and a software-based version. This is done in order to show how the framework can be implemented.

The framework has been developed primarily on the basis of a theoretical analysis of the IT evaluation methods and an empirical data collection from the five case studies in which four methods were used. Two important aspects in the case studies are parts of the framework development. First, the methods' usefulness in each of the case studies was identified and, second, the identification of the parameters influencing the choice of method.

The framework is tested with regard to the validity of its output by using it on the five case studies. This is done in order to ensure that the framework is consistent with the experience gained in the case studies' of the four methods. The two implemented versions of the framework were also demonstrated to a number of IT managers from the case study companies in order to get feedback on the usefulness of the framework, which in general was positive.

The research presented in the thesis has shown that that the framework is useful for choosing the best matching IT evaluation method, and using the framework can improve a company's IT evaluation practice.

## 13.5 Further research

The last section in this chapter focuses on the possibilities for further research, which is either inspired by this thesis or more directly based on the thesis. Furthermore the commercial and research-based interests are discussed.

### 13.5.1 Research possibilities

This thesis only focuses on a small topic within the field of IT evaluation in the context of construction, and there are many topics yet unexplored. The research possibilities can be divided into two areas depending on the relationship with the thesis.

**Direct relationship with the thesis**

An obvious research possibility is to expand the data material used to derive the parameters, the attributes and their relationship with the IT evaluations methods. This would increase the framework's usability as more aspects can be included in the framework (e.g. more company types) and the data/knowledge in the framework is more representative of companies in the construction industry. This could be done by completing another series of case studies using the same type of data as that collected in the five case studies.

As mentioned in one of the limitations described above, the framework only includes four methods whereas the number of identified methods is 82. Including more methods could therefore be considered as one of the research possibilities for enhancing the usability of the framework. This requires that they are tested in a series of case studies where the characteristics of the IT evaluations are different from each other.

Another research possibility mentioned is to initiate a thorough test of the framework. Ideally this should be done, as described above, by both testing the validity of the framework's output in other case studies, and by completing a more detailed examination of the framework's influence on companies' IT evaluation practice. This would require a significant amount of resources (mostly time), as several case studies would be needed to complete such a test.

The last research possibility that can be directly related to the thesis, is to investigate the value of improving a company's IT evaluation practice. This topic is very relevant to the thesis as the main benefit of using the framework is an improved IT evaluation practice. Completing research with this purpose requires an extensive investigation of the costs and benefits of using the framework in a series of companies, compared to a series of companies, not using the framework. This research possibility is not significantly different to that previously mentioned and therefore it would require a significant amount of resources to complete the number of case studies needed.

**Topics not directly related to the thesis**

In the case studies there was found to be a need for research to be undertaken in the topics of identifying and estimating the costs and benefits of an IT investment. This is not a new research area as several researchers have been working on it, for example (Lincoln et al. 1990), but for some unknown reason it has not been adopted by most of the available IT evaluation methods. The four methods included in the framework give, for example, very little guidance on how to complete these activities even though they are central to the methods. To complete this research possibility would require a study of how costs and benefits related to IT investments can, and should, be identified and estimated.

The last research possibility mentioned, which is not directly related to the thesis, is to complete an examination of the processes in an IT evaluation champion's decision making. This examination could reveal how people, who are facing the difficulties of IT evaluations, are handling the process. The knowledge gained could be used to develop tools that more accurately fulfil the need. Completing such research requires that the researcher has the opportunity to follow and observe a number of IT evaluation champions in their daily work.

### 13.5.2 Commercial possibilities

The most evident commercial possibility is that companies from the construction industry implement the framework as a part of their IT evaluation practice. This would enable the company to choose a method, that uses a formal IT evaluation procedure, and thereby improves the company's IT evaluation practice.

The ultimate aim of improving the IT evaluation practice is to enable the company to improve the usage of their IT investments and thereby increase "Value for Money" for all their IT investments. A result of this would be that companies from the construction industry were better at allocating their resources to the best IT investments whereas bad IT investments could be more easily avoided.

Software companies can benefit from the software-based version as it can be used as a prototype for commercial software developments. The software-based version could, for example, be expanded by including the available methods, so that the user is guided through both the selection of the method and the actual IT evaluation. An expanded commercial version of the framework could therefore be sold to companies from the construction industry.

Another group that can benefit from the thesis is consulting companies. The work in the thesis is very relevant to consulting companies that focus on IT consultancy, as this gives them a better knowledge of how to select an IT evaluation method in the context of construction.

Based on the descriptions above, of the possibilities of both research and commercial use, it is concluded that there are many topics which still need to be covered, but also that this thesis is a small step forward which can benefit both research and practice within the construction industry.

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