

23 COST AND BENEFIT ASSESSMENTS OF IT SYSTEMS IN THE CONSTRUCTION INDUSTRY

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23.1.1 *Abstract*

This paper describes five case studies in which four IT evaluation methods have been used to complete a cost and benefit assessment of different IT investments in companies from the Danish construction industry. It also compares the usage of the framework Measuring the Benefits of IT Innovations, which also has been used on a few English case studies. The evaluated IT investments in the Danish case studies are (1) upgrading to AutoCAD 2000, (2) implementation of Documentum WorkSpace, (3) a strategy for usage of project webs, (4) choosing between two project webs and (5) implementation of a CITRIX application. In the English case studies the following IT investments were evaluated; (1) implementation of DOCS Open and (2) implementing a company wide Intranet. The experiences of completing the five case studies in Denmark have been that Net present Value in most cases produced a negative output whereas the methods Information Economics and Measuring the Benefits of IT Innovation showed a more positive output. The last method Critical Success Factors was found to be less useful because of the format of the output. Completing the IT evaluations revealed that two major activities are difficult to complete. First it was found difficult to identify the benefits and second, the estimates of the benefits' value were generally considered as very uncertain.

Keywords: *IT evaluation methods, case studies, costs and benefits assessments*



INTRODUCTION

Evaluating IT investments cannot be considered as a new idea or trend because it, to some extent, has existed as long as IT investments have (the first commercial computer was released in 1951). However, the first known author on a related subject is E.O. Joslin, who wrote a book on computer selection back in 1968 (Joslin 1968). Since then a growing literature has emerged focusing on the subject.

Some cross-sectional surveys show that an increasing amount of money is invested in IT. For example, in the UK there was an estimated spend of £44.4 billion on IT in 1998 and this has gone up by 5% compared to 1997 (Willcocks 1996). The fact that an increasing amount of money is spent on IT worldwide highlights the importance of identifying the *Value for Money* of IT investments in all types of companies.

Focused specifically on the Danish construction industry there is an estimated turnover of approximately 225 billion DKK (£1 is approximately worth 12 DKK), this include building material suppliers, consultants, contractors, building owners and the support industry (Erhvervsfremme Styrelsen 2000).

Table 1 shows the approximate investment in IT for consultants and contractors in the Danish construction industry in the year 2000.

	Consultants	Contractors
Turnover (million DKK) ¹	11.702 ²	67.285 ³
IT investment percentage	2%	0.25%
IT investment (million DKK)	234,0	168,2

¹Turnover data is taken from (Erhvervsfremme Styrelsen 2000)

²Turnover for consultants is calculated on the basis of their fee

³Turnover for contractors is calculated on the basis of the value of the building projects

Table 1. IT investment in the Danish construction industry for year 2000

Considering the fact that the approximate investment in IT for the year 2000 was 234 million DKK for consultants and 168 million DKK for contractors in the Danish construction industry, it is argued that the companies should be interested in what the *Value for Money* is of their IT investments.

Despite this fact, surprisingly little attention has been paid towards evaluating IT investments in the Danish construction industry (Andresen 2000). Other countries' construction industries seem to experience the same problem (Churcher et al. 1995). The present paper is therefore focusing on how these companies can improve their IT evaluation practice.

PURPOSE OF CASE STUDIES

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

Using four different IT evaluation methods

The primary objective of the case studies is to use four different IT evaluation methods on different companies and different IT investments. The methods used are described in a later section. The important focus is on how the methods support the IT evaluation in each of the case studies and less on the actual outputs of the methods (even though this is an important part of the methods).

The aim of testing four different methods in different case studies is to collect information on the usefulness of each of the methods in the actual IT evaluation. The hope is that this will provide information about which method is useful in which IT evaluation.

Identify types of IT evaluations

Secondly, the objective is to identify and describe different types of IT evaluation. IT evaluations are very different from each other because they consist of many factors. Completing a series of case studies provides information on different types of IT evaluation.

Identifying different types of IT evaluation will be used to base the foundation of the guide on how to choose the best IT evaluation method in a specific case. The number of IT evaluation types can theoretically be considered as unlimited whereas the number of case studies is five. This limits the scope of the case studies but this was necessary because of the practical limitations.

Practical problems experienced in IT evaluations

The third objective is to experience and identify the problematic areas in conducting IT evaluations faced in practice. It is believed that completing IT evaluations will provide some information on the problems of evaluating IT investments.

The practical problems experienced together with a theoretical review of the four IT evaluation methods' strengths and weaknesses will provide an overview of the barriers in conducting IT evaluations. Collecting information on problems in conducting IT evaluations can be used to describe how they can be improved in the construction industry.

Evaluating IT investments with relevance to the construction industry

In relation to the first objective, the last objective is to collect information on different typical IT investments a typical consulting engineer or contractor will have to evaluate. The IT investments evaluated are relevant to companies from the construction industry.

Collecting and presenting information on how different IT investments have impact on a company can be useful to 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 applicable to other companies. It may, however, give some insight into the impact of the IT investment.

CASE STUDY METHODOLOGY

The criteria for the selection of the five case study companies were (a) only consulting engineers and contractors operating in Denmark, (b) an actual need for the IT evaluation, (c) the company's use of IT should have reached some level and (d) at least four case studies should be completed.

Some of the criteria used in the selection were based upon the possibility of triangulating the data collected (Yin). This was achieved through limiting the types of companies and by completing at least four case studies. The second criterion was important because the case studies should describe an actual IT evaluation and not be considered as a purely academic exercise.

In total 12 stages were completed in each case study.

■ Describing the company

The first stage is focused on describing the company with regard to the following areas: strategy, organisation, technology, human resources, objectives and its environment. The primary objective of this stage is to collect information about the company and to get an insight into 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 be tested. This stage is also focused on describing the IT evaluation with regards to the purpose and 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 their existing IT systems. The primary objective of this is to identify how sophisticated (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. The lifetime of the IT investment should be estimated on the basis that no major investment or upgrading is necessary during this period.

■ Identifying the benefits

This stage is the first step in completing the financially oriented IT evaluation methods. Identifying the benefits of using the IT investment is a common element of these methods and is therefore only completed once. There is, in this stage, no limitation on the types of benefit identified.

- **Categorising the benefits**

This stage focuses on categorising the benefits into three different categories: economically measurable, measurable (other measurable benefits) and non measurable.

- **Estimating costs and benefits**

After identifying and categorising the benefits, the estimation of each benefit's value is completed. The estimation of the benefits' value is completed on a yearly basis and is only done for the economically measurable benefits. Also the costs are estimated using two categories: investment and running costs.

- **Completing Net Present Value (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 needs to be estimated in order to complete this method and this is the rate of interest.

- **Completing Measuring the Benefits of IT Innovation (MBITI)**

The second method completed is MBITI. First, the strategic part of the framework is answered and second, the three tables are filled out using the already identified and categorised benefits and their estimated attributes. The presentation sheet can then be completed on the basis of the method's three tables.

- **Completing Information Economics (IE)**

This stage focuses on completing the method IE. Three different domains are completed: the economy, the strategic and the technology domain. Last 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 Critical Success Factors (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.

Some of the methods (NPV, MBITI and IE) require the same data (the economic data) and it was therefore decided to complete the identification and estimation 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 economic data it was completed separately.

The primary sources of information were collected through semi-structured interviews, meetings, reports/homepages and a questionnaire.

PRESENTATION OF CASE STUDIES

The three consulting engineer are represented in the top five (ranked by their turnover) in Denmark. One of the consulting engineers is, however, significantly smaller than the two others. Of the contractors, one is the largest of its kind in Denmark whereas the other has a turnover about forty times smaller than the first.

Table 2 shows some of the relevant characteristics of the 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	1,328.5	325.3	3,985.3	100
No. of employees	1,856	2,099	<500	3,126	275
Geographical span	Denmark & International	Denmark & International	Denmark & International	Denmark & International	Local
IT investment (as percentage of turnover in 2000)	4.1	7.4	0.4	0.34	0.25

¹CE ~ Consulting Engineer

²CO ~ Contractor

Table 2. Characteristics of the case study companies

In combination the case study companies represent a range of different characteristics within the group of consulting engineers and contractors.

The five IT investments, that have been evaluated in the case studies, are all, to some extent, relevant for companies from the construction industry because they represent IT investments that are likely to be used and evaluated in these companies.

The IT investments can be further characterised as seen in *Table 3*.

	Rambøll	Cowi	NIRAS	Højgaard & Schultz	Troels Jørgensen A/S
IT investment	Upgrading to AutoCAD 2000	Implementing Documentum WorkSpace	Choosing a project web strategy	Choosing between two project webs	Implementing a CITRIX application
Type of IT investment ¹	Automation	Direct Value Added/Strategic systems	Automation	Inter-organisational systems	Infrastructure
Main impact	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	<ul style="list-style-type: none"> ▪ CAD operators ▪ Engineers 	<ul style="list-style-type: none"> ▪ CAD operators ▪ Engineers ▪ Project members 	<ul style="list-style-type: none"> ▪ Project leaders ▪ Project members 	<ul style="list-style-type: none"> ▪ Project leaders ▪ Project members 	<ul style="list-style-type: none"> ▪ Administrative staff ▪ Conductors
Stage of IT investment	Upgrade or dismiss IT system	Implement IT system	Consider new IT investment	Decide IT system	Implement IT system
Purpose of IT evaluation	Identify the timing of the IT investment	Measuring the benefits achieved	Identify the best strategy	Choosing between two IT applications	Estimating the impact

¹The type of IT investment is determined using (Farbey, Land, & Targett 1993)

Table 3. Characteristics of the evaluated IT investments

The characteristics shown in *Table 3* are displaying the differences in the IT investments that have been evaluated. Especially important is the last characteristic in the table, which describes the purposes of the IT evaluations. It shows that the case studies are very different with regard to the purpose of the IT evaluation.

PRESENTATION OF IT EVALUATION METHODS

Four IT evaluation methods have been tried on the case studies. Each of them represents a larger group of IT evaluation methods.

The methods used are the following

- Net Present Value (Atrill & McLaney 1997; Brealey & Myers 1988)
- Measuring the Benefits of IT Innovation (Construct IT 1998)
- Information Economics (Parker & Benson 1988)
- Critical Success Factors (Rockart 1979)

The format of the methods' output needs to be described and can be seen in *Table 4*.

	Name of output	Measurement unit	Description
NPV	Net present value	DKK	Shows the present financial value when the net cash flow is discounted to the present
MBITI	Efficiency	DKK	Displays the money savings in the company
	Effectiveness	Ratio	Shows the degree of measurable benefits achieved Ratio is between 0 and 100.
	Performance	No.	Displays the number of non-measurable benefits
IE	Total value	Ratio	Shows the total value of the IT investment for the company. Ratio is between 0 and 150.
	Total risk	Ratio	Displays the total risk of the IT investment for the company Ratio is between 0 and 100.
CSF	Critical success factors	No.	Displays the number of critical success factors

Table 4. The description of the IT evaluation methods' output

Many IT evaluation methods are available today and all of them are unique in some ways. Renkema and Berghout have, in their paper, identified 65 different IT evaluation methods and many others have been developed since (Renkema & Berghout 1997).

The many available IT evaluation methods can be categorised according to many different criteria such as objectives, data need and output format. Examples of different categorisations can be seen in (Farbey, Land, & Targett 1993; Twite, Money, & Remenyi 1991).

In this paper the IT evaluation methods are categorised as follows.

- Financial
- Multi criteria approach
- Exploratory

It is argued that at least one the four chosen IT evaluation methods represents each of the three categories. The relationship between the categories and the four chosen IT evaluation methods can be seen in *Table 5*.

Category	IT evaluation method
Financial	Net Present Value
Multi criteria approach	Measuring the Benefits of IT Innovation Information Economics
Exploratory	Critical Success Factors

Table 5. Relationship between categories and methods

A more detailed description of the categorisation and the available IT evaluation methods can be seen in (Andresen 1999).

OUTPUT FROM IT EVALUATIONS

The four methods were successfully completed in four out of five case studies. In the last case study it was not possible to collect the necessary numerical data and therefore the financially oriented methods could not be completed.

The outputs of the methods in each of the five case studies can be seen in *Table 6*.

		Rambøll	Cowi	NIRAS	H&S ¹	TJAS	
NPV	(DKK)	-599,263	-8,637,789		-400,489	-177,637	316,963
MBITI	Efficiency (DKK)	460,000	8,516,993		239,830	305,000	657,000
	Effectiveness	Not applicable	Not applicable		Not applicable		Not applicable
	Performance	8 identified	8 identified		20 identified	20 identified	9 identified
IE	Total Value	41	108.25		67	67	72
	Total Risk	4	10.5		26	24	26
CSF	No. of CSF	12 identified	20 identified	10 identified	19 identified	21 identified	7 identified

¹Two different project webs have been evaluated at H&S and therefore the table contains two outputs in this column

Table 6. Outputs from the IT evaluation methods

Net Present Value

NPV was used on four out of five case studies and a clear tendency has been experienced using this method. Three out of four IT investments would not be approved according to this method. This strongly indicates that the method is very restrictive in its approval criteria and may therefore not be useful in evaluating most IT investments. Many IT investments are delivering qualitative benefits and these are not taken into consideration if this method is used. It can therefore be concluded that the method is not useful in evaluating IT investments that deliver a significant number of qualitative benefits.

Measuring the Benefits of IT Innovation

MBITI was successfully used on four out of five case studies. In two of the case studies it was found to be frustrating that the framework did not provide specific guidance on how to use it. It has some difficulties in clearly describing and explaining some of the definitions used e.g. the differentiation between the 10 business processes used in the tables.

In those case studies where MBITI was applied successfully it was found that the second table was not used because none of the identified benefits were categorised as effectiveness. In a few of the case studies there were, in the first attempt, identified benefits of this type but they were eventually either deleted or re-categorised as performance benefits. This strongly indicates that this table is either focusing on very rare benefits or that the table is difficult to understand and use.

The outputs provided by MBITI were found to give a detailed insight into the expected impact of using the IT investment in the company but were judged as less suitable for decision-making because of the difficulties in achieving an overview of the multiple outputs.

Information Economics

IE was successfully completed on four out of five case studies. It was, by several of the evaluators, identified as the best method. The method was found to be logical and well-structured with several good concepts. There was, however, experienced one difficulty with the concept, called Value restructuring, because of its unrealistic data requirements. It was only found applicable in one case and even here the evaluator expressed serious doubt about the preciseness of the estimates (the data) used in the concept.

Critical Success Factors

CSF was completed on all five case studies. The method is producing an output which can provide an insight into how the different (and relevant) stakeholders view the IT investment, and should primarily be considered as a method that provides some critical factors that have to be fulfilled in order to ensure that the IT investment is successful. The relevance of the method is, in the five case studies, not significant as most of them are focused on identifying and estimating the cause and effect of the evaluated IT investment.

It is considered as very poor in examining the economic dimension of the IT investment but may include many other dimensions like strategy, technology, risk etc. The method's main strength is identifying and clarifying the requirements of the IT investment and may increase the common understanding of what is needed in the company.

General comments

The four IT investments (which have been analysed using the financially oriented methods) are likely to be approved if either MBITI or IE is used, whereas only one IT investment would be approved using NPV.

In general CSF was not found useful in four out of five case studies, primarily because of the format of the method's output.

COMPARING CASE STUDIES IN DENMARK AND UK

During a six month stay at the University of Salford the framework MBITI was used on three case studies. The companies involved were: Costain, Taylor Woodrow and Alfred McAlpine. The case study companies are all contractors that have a higher turnover than the largest Danish contractor. In that comparison Højgaard & Schultz is considered as small.

The case study completed with Taylor Woodrow was not focused on using the framework on specific IT investments. The company had adapted and amended the framework and therefore the differences between the original and their version were analysed in order to identify how the framework could be improved. A few examples of the use of the strategic part of the framework were obtained. These are not commented on in this paper.

The IT investments, which have been evaluated, can be seen in *Table 7* together with the outputs produced by MBITI.

		Costain	Alfred McAlpine
IT investment		Implementing DOCS Open	Implementing a company wide Intranet
MBITI	Efficiency (£)	188,918	7,900
	Effectiveness	100	Not applicable
	Performance	10 identified	13 identified

Table 7. Outputs from MBITI in UK case studies

In general the same problems were experienced as in the Danish case studies when the method was used. For example the use of the effectiveness benefit table was small because the evaluators only differentiated the benefits between tangible and intangible and they found it therefore difficult to identify benefits that could be characterised as non-economically measurable.

Both the identification and estimation of the costs and benefits were experienced as difficult. One of the difficult questions was how to define a proper measurement, which would reflect the realistic benefits.

LEARNING FROM THE CASE STUDIES

A common weakness of the first three methods (the financially oriented methods) is the lack of guidance on how to identify the benefits of the IT investment. As previously described in the case studies, one of the major 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 estimations were generally found to be easier to complete than the benefits. Estimating the benefits requires a very individualistic 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 especially can, in some cases, be encumbered with so great an uncertainty that they are useless in practice.

Not having guidelines for these two activities can, in extreme situations, make the IT evaluation very vulnerable to the evaluators' subjectivity, or to amending the data in order to achieve desired outputs because of 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 a formal method. It is therefore

considered as very important that some guidance on these two activities is included in the financially oriented methods.

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 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 is 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 data. 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 financially oriented methods are basically focused on identifying and estimating the cause and 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 is, in the completed case studies, low 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.

An important conclusion is that none of the four methods can be considered as perfect, but they may have certain advantages in certain situations.

CONCLUSION

This paper has presented five case studies in which four different IT evaluation methods have been tested. Using the methods it has been shown that the output is very dependent on the methods used. Using NPV revealed that three out four IT investments would be rejected, whereas MBITI and IE in general show more positive outputs. Whether the IT investments would be approved on the basis of these outputs is difficult to conclude because it depends on the company's approval criteria.

It was found that two major difficulties are making the IT evaluations problematic to complete. The first difficulty is the process of identifying the benefits. It should be acknowledged that this process has to be applied to the specific IT evaluation but some general guidelines of how to identify the relevant benefits would be considered as a valuable aid. It was secondly found difficult to estimate the value of the economic benefits. The evaluators often felt that the estimations given were too imprecise and therefore required a further examination. Two situations were experienced where either the evaluator accepted the result or began to specify the benefits in greater detail. None of the financially oriented methods used provided useable guidance on these two subjects.

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