EVALUATING THE USE OF BSC-DEA METHOD IN MEASURING ORGANIZATION’S EFFICIENCY

Master’s (one year) thesis in Informatics (15 credits)

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Autumn 2010: MI09
Title: Evaluating the use of BSC-DEA method in measuring organization’s efficiency

Year: 2011

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Abstract

In today's business environment, organizations try to improve their efficiency in order to have more power in the global competition. This requires capabilities to detect and evaluate the impact of Information Technology (IT) on the organization's efficiency.

There are some difficulties in evaluating the impact of IT on the organization’s efficiency. For example, one should consider many quantitative and qualitative factors in the evaluation process. For solving these kinds of problems, this thesis proposes a methodology to identify the effects of IT investment and the importance of IT related activities on the organization’s efficiency, within the BSC-DEA model.

In the first parts of thesis, the Balanced Scorecard is used as a performance management tool for evaluating an organization’s efficiency. The four dimensions of the Balanced Scorecard link organization’s strategies with indicators and help the management establish an integrated efficiency assessment system for evaluation of IT investment. This thesis has studied some shortcoming of BSC for efficiency measurement and argued that DEA has the advantage to fill these shortcomings of BSC and to better evaluates impacts of IT on the organization's efficiency.

In the Second part of this thesis, I have shown that the DEA model generates one single efficiency figure in multi-input and multi-output situations. DEA performs the optimization analysis on each individual unit (DMUs) and generate relative efficiency value of each DMU. In this way, the integrated BSC-DEA model is constructed. For a better explanation of proposed BSC-DEA model, I presented and analyzed an example in the final part of the thesis.

The presented model has two major benefits in subjected area:

Firstly, It Combines two well-established managerial methodologies and proposes a new approach to evaluate IT effects on organizations. This approach uses “BSC” as a comprehensive framework for defining evaluation criteria with regard to IT investment and uses “DEA” as a nonparametric technique for ranking organization performance with those criteria. The second contribution is that with the comprehensive view which BSC gives us and with efficiency measure that DEA calculates, we can have a dependent variable to study how and why some organizations use IT better than others.

Key Words: Balanced scorecard, Data Envelopment Analysis, IT investment’s effects
Acknowledgements

I would like to thank my tutor, Dr. Anders Hjalmarsson, for his great support through this thesis process, his competent suggestions and his encouraging attitude.

I am also thankful to all the professors in school of business and informatics in University of Borås who helped me during my studies.

I also like to extend my appreciation to all who helped me during this thesis.

Borås January 2011

Pooria Niknazar
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1 Introduction

1.1 Background

In today's business environment, organizations try to improve their efficiency to have the power in the competition. This requires capabilities to detect and evaluate the impact of Information Technology (IT) on the organization's efficiency. This allows organizations to perform well compare with the competitors in the global marketplace (Quan et al., 2003).

Several studies have studied the impact of Information Technology (IT) on performance of organization in recent years (Wang et al., 1997).

Andresen (Andresen, Jan L., 2001) has studied different IT evaluation method. He has found 82 different evaluation methods, and has done a survey on Danish companies. Based on theoretical and empirical works, Andresen has proposed a framework. It consists of a number of parameters, which can describe different IT evaluation methods, as Anderson experienced in the Danish construction companies. In his work, Each IT evaluation method is compared with a number of the IT evaluation methods and the best match is identified.

Anderson (Andresen 2001) has concluded that:

1- Finding the best evaluation method for all cases is impossible.
2- The use of the framework for the identification of the best matching IT evaluation method improves organization’s evaluation practice.

One of the main sources for this thesis Abbas & Asosheh (Asosheh et al., 2010) work. They have integrated widely recognized techniques, BSC and DEA and have introduced a new approach for ranking IT projects. The proposed approach exploits BSC as a framework for defining R&D project selection criteria. Proposed BSC for IT projects considers five perspectives – four original perspectives of BSC and an uncertainty perspective. Uncertainty perspective is added to emphasize its role in R&D projects. Furthermore, Asosheh introduced a new DEA method for ranking IT projects with imprecise data.

Abbas & Asosheh (Asosheh et al., 2010) argue that the optimal selection process is a significant strategic resource allocation decision. Optimal selection appoints the organization in significant long-term commitments. However, making these kinds of decisions is not easy because there are many quantitative and qualitative factors in the evaluation process. Therefore, there is a need for further research in this area.

Wang & Gopal (Wang et al., 1997) have developed a methodology within the DEA framework to identify the effects of IT utilization and IT related activities on the organization’s performance. Their methodology also evaluates the marginal benefits of IT.
Eliat and Golani (Eilat et al., 2008) also employ a multi-criteria approach for R&D project evaluation. They have combined concepts taken from DEA and BSC. They have proven this method to be useful measurement and analysis tool. DEA and BSC concepts were integrated into a single BSC-DEA Model and the models discriminates projects according to the desired characteristics. Eliat and Golan’s DEA- BSC model ranks the projects in a manner that is consistent with the organizational strategy.

With the help of this paper (Asosheh et al., 2010), I propose my model not only for projects, but for whole organizations. With the help of (Wang et al., 1997) and (Eilat et al., 2008) I have developed the integrated approach that I wanted to present in this thesis.

1.2 Statement of problem

As stated in previous part, evaluating the impact of IT on organization performance is difficult because there are many quantitative and qualitative factors. In addition, alignment between business strategy and information systems strategy is a major issue in organization efficiency. We should look for a tool that considers all of these issues in order to evaluate organization’s efficiency.

Many researchers have criticized the overemphasis on short-term financial results that can cause a bias towards investment in organizations. It can cause the insufficient IT investments with long-term benefit for the organization. BSC is a tool that helps managers in these issues. However, BSC itself has some problems like: there are a large number of variables that cause complex optimization problem (Rickards, 2003), the lack of a common scale of measurement and Not having a baseline or benchmark which performance is measured against.

Furthermore, BSC does not have a mathematical model or a weighting scheme so it is difficult to make comparisons within and among the organizations. In addition, BSC does not have a comprehensive index to summarize the interaction between measures of performance.

This thesis tries to address and solve all of these problems with its BSC-DEA method.

1.3 The purpose of the study

For solving the stated problem, this thesis investigates if we can use BSC-DEA as a methodology to identify the efficiency of IT utilization and the importance of IT related activities towards realizing firm efficiency. This thesis has two main contributions to these problems.

Firstly, It Combines two well-established managerial methodologies, balanced scorecard (BSC) and data envelopment analysis (DEA), and proposes a new approach to evaluate impact of IT in organization’s efficiency. This model uses “BSC” as a comprehensive framework for defining
evaluation criteria with regard to IT investment and uses “DEA” as a nonparametric technique for ranking organization performance with those criteria.

The second contribution is that with the comprehensive view which BSC gives and with efficiency measure that DEA calculates, we can have a dependent variable to study how and why some organizations use IT better than others.

1.4 Research questions

‘What are the IT effects on Firm-level efficiency?’

‘How can BSC-DEA model help us to better evaluate organization’s efficiency?’

‘What are the marginal effects of IT on organization’s efficiency?’

‘What are the managerial results of efficiency evaluation with BSC-DEA method?’

This thesis will address the first two questions in the literature study. After confirming that IT has a big impact on a firm efficiency, this thesis will evaluate if the proposed model is good enough for evaluating organization’s efficiency or not. The last two questions that are the sub questions, study how we can better design our DEA-BSC method and how we interpret its results.

1.5 Target group

An obvious target group is researchers within Performance area and strategic management of IT, informatics, or interdisciplinary fields. The result presented in this thesis cab is as a background for further research about how to better evaluate the impact of IT investment on the organization’s performance and organization strategic goals.

In addition, those researchers who are working on integration of DEA or BSC with other methods can use this proposed model as a fundamental framework to develop their researches.

1.6 Delimitation and limitations

1. Most of previous studies have implicitly assumed that all organizations utilize their information systems efficiently. Therefore, it will be hard to interpret the evaluation results precisely.

2. We cannot define clearly, when IT investment in every year has its full impact on organization performance.
1.7 Structure of the thesis

In the introduction part, previous researches are presented. After that, I have presented the Research questions and the purpose of research. Then relevance of this thesis title to informatics is argued. Next, the Procedures / methods chapter describes the perspective and strategy that this research is based on. It also illustrates the scientific approach and presents an overview of the methods used for evaluating the research results.

In the Literature study, I look at most of previous studies and researches concerning BSC and DEA. Then, I will present Balanced Scorecard (BSC) which Introduce BSC and its usability for my presented model and then by presenting Technical efficiency definition and data Envelopment Analysis (DEA) model. I will explain DEA’s usability for my presented model after that.

After getting to know BSC and DEA, I argue the effects of IT in the organization's efficiency. Then the integration of DEA and BSC is introduced. Next, in the two long tables I will show the complete BSC for evaluation IT investment’s effect on organization’s efficiency.

In the 9th chapter, to show how DEA will function in the integrated BSC-DEA model, an example is solved. Evaluation of the results would be a major point to understand the meaning of this integrated model.

At the end, the conclusion of this study and scientific and practical contribution of this thesis is presented. Suggestions for further research will follow the conclusion.

2 Procedures / methods

2.1 Research perspective

There are two main types of data collection: quantitative and qualitative methods. The aim with a quantitative approach is to study relationships between different concepts or to investigate the distribution of earlier defined phenomenon. The qualitative approach investigates variations, structures, and processes for the phenomenon that are not quite known.

Here, I characterize the two-step of my work and based on this characterization, I argue that Integrated BSC-DEA model uses both perspective, thus it is both qualitative and quantitative.

In the first Step, Balanced scorecard (BSC) as a method, considers all aspects of an organization with a holistic view. As BSC categories and tries to understand the reality of organization in social and human experiences beside the financial matters, so we can consider it as a qualitative approach.
In the second Step, nonparametric frontier method of data envelopment analysis (DEA) is employed to measure technical efficiency scores of firms. DEA used quantitative data and produce quantitative results so we can regard it as a quantitative approach. It is because the quantitative research’s result is consists of quantitative data (Andersen, H, 1994).

Integrated BSC-DEA model uses both BSC and DEA in its process. Therefore, we are using quantitative and qualitative approaches at the same time. The presented model (BSC-DEA) results are credible from both perspectives as I addressed in conclusion part. Showing the benefit both from BSC and DEA perspectives validates the results of this study. So based on the characterization of knowledge (BSC-DEA results) implies that my approaches for integrated model is a qualitative-quantitative.

In a simple word, BSC has qualitative approach and DEA has quantitative approach. Therefore, BSC-DEA has both of these approaches (qualitative-quantitative)

2.2 The roles of the theoretical and the empirical study

In order to clarify the research strategy, we should address the role of the theoretical and the empirical study. The theoretical material can influence the researcher when selecting data (Bryman, 2002) The theory can also be a result of a research (from the collected and analyzed data).

The first part of this thesis sees the problem areas from different researchers and author’s points of views. These researchers have different perspectives. They are representing different research areas. Previous theories are used to illuminate the process of knowledge creation through strategic management and BSC concepts. I tried to find some influencing factors to use in DEA as a base for knowledge creation. Therefore, the first part, which explains BSC and DEA, is the theoretical part of this thesis.

I showed the usefulness of integrated BSC-DEA, based on different previous researches. Based on their results, these researches address this integrated BSC-DEA model, as a theory. I have also used BSC-DEA model and have localized it for IT world.

We should bear in mind that Empirical studies has a major role in theory and reasoning of Balanced Scorecard. Here, based on these two models, I have raised a theory (Integration of BSC and DEA for identification of IT effect). Results from the theoretical research can be verified through the empirical survey that adopts the BSC-DEA method.

The empirical survey however aims at finding benefits of integrated model for performance measurement of an organization. For example, Eliat and Golani(Eilat et al., 2008) did an empirical survey and used BSC-DEA model and presented the expected results as a basis for proving their theory behind BSC-DEA integrated model. The Analysis of successful results from previous empirical studies about BSC-DEA will also give contributions to the existing theory of Strategic management view of efficiency measurement.
In this thesis, due to limited time and empirical survey was not possible so just an example in given to clarify how the integrated model works.

### 2.3 Research strategy

An evolutionary study is a study where the results appear in steps. Later research results are based on previous results thus forming a chain of interrelated results leading forward towards a composite result. (Andersen, 1994)

The character of my study is mainly evolutionary. From one of the main sources of this thesis which is ‘Information technology project evaluation: An integrated data envelopment analysis and balanced scorecard approach’ (Asosheh et al., 2010), I took a framework as the base for my thesis.

I used the evolutionary approach when I completed mentioned framework. I used Asousheh’s framework for the whole organization. Then I used ‘R&D project evaluation: An integrated DEA and balanced scorecard approach(Eilat et al., 2008)’ to better design the DEA-BSC model.’ Relating the perspectives of the balanced scorecard for R&D by means of DEA (García-Valderrama et al., 2009)’ also had a major influence in evolution of my work. So based on all of previous studies, I have integrated and have completed them with a proposed model to identify the impact of IT utilization and the importance of IT-related activities in firm performance.

### 2.4 Data collection methods

The qualitative methods that I used to collect data for my research were text analysis and Text sampling. Reading written material and then analyzing is text analysis. In the text analysis, I summarize the opinions of many authors in order to reach a standpoint that is relevant to my research.

I use different texts to create a scientific base for the problem area of my research. I used these different texts to describe the process of knowledge creation with integration of Balance scorecard and Data envelopment Analysis and to analyze results of proposed model.

Scientific textbooks contain the results of previous research and accepted examples of scientific practice therefore, Text sampling is the base for further research(Kuhn, 1996). I found such results and examples as a connection to previous established knowledge within the area of strategic management, efficiency measurement, and IT investment.

One sampling method is to state some criteria and use them for choosing literature for the text analysis (Patton, 2002). I have stated some criteria that I have used when looking for literature.
Since the research relates to an integrated model, I will choose literature both from the efficiency measurement like the DEA and strategic management like BSC.

I also identified Cognitive authorities by using different sources especially in the integration of BSC and DEA. Authors that have contributed to the subject area and who are often referred to by their peer have the priority in my resource selection.

To gather literature for my research I have looked in Elsevier, Sciencedirect, Libris (National library of Sweden) and online library of Högskolan i Borås. In these sources, there are high quality papers about integration of DEA and BSC in credible journals. I have also found some material relevant for my research on the search engine Google.

### 2.5 Analysis method

To reach a good understanding for the problem area of the research and to identify important concepts, it is necessary to perform a text analysis. It is important to have a strategy for this procedure. One important aim of the analysis is to create a deeper meaning than the immediate obvious and the research approach. Data for analysis in my research come from text analysis of different sources and from the results of DEA.

During my investigation, I analyzed this thesis’s main sources and selected some text with regard to their relevance to my subjected area. Relevance to information technology investment and implementation is an important criterion for my analysis. Getting data from text analysis and text sampling together with DEA model, we can run the integrated model and analyze its results.

The results of DEA are the bottom line of the BSC-DEA integrated model. The efficiency measures that DEA calculates should be analyze together with the ‘Slacks’ report that DEA calculates. We can perform a good analysis with having these two kinds of data (Efficiency scores and Slacks reports).

Prior knowledge to interpret DEA results is necessary to better analyze and to interpret the results of this study. Knowing how DEA works and how it ranks DMUs is very helpful to interpret the results. A quantitative analysis best describes the nature of interpreting the results of DEA.

### 2.6 Strategies for validating findings

First strategy is to compare a series of literature studies. It provides data on different types of IT evaluation that shows the usefulness of the development in this area and validates the proposed DEA-BSC model.

Impact of IT investment on organization’s efficiency can be shown in ‘the shift from economic benefits in the investment stage, to client and employee satisfaction’. Because the character of
my study is mainly evolutionary, based on previous literature study’s findings, combined with reasoning through BSC-DEA model try to validate this thesis findings.

In addition, Comparing Companies’ situation with the Criteria like Quality improvements, Time reduction, Client satisfaction and Employee satisfaction after IT investment, will validate BSC-DEA results. Analysis of DEA results shows this comparison.

In the next chapter, to have a base for presenting our model and to have the literature study, Theory of production and technical efficiency is studied.

3 The strategic value of IT

3.1 Alignment between business strategy and IT strategy

IT is not only a support for efficient business operations and decision making; but IT has a role in the way that businesses compete (Ruiz-Mercader et al., 2006) Therefore, IT is a crucial tool for organizations to get a competitive advantage (Tseng, 2008). In many organizations, IT managers usually have many responsibilities and have a connection with all other departments so they can have a direct influence on strategic path of the organization.

Many researchers have found that alignment between business strategy and information systems strategy has a significant effect on the organization's expense. They indicate that investments in tasks with the aim of growth is directly related to firm revenue (Quan et al., 2003, Camanho and Dyson, 2005, Oh and Pinsonneault, 2007)

Alignment and organizational performance typically assumed to have a linear relationship. Due to the rapid change in business environment, Small differences in the degree of alignment have a big impact on the performance (Oh and Pinsonneault, 2007). In this kind of environment, the formulation of business strategy is essential for survival. In 1999, Anderson and Meyer studied the relationship between business strategy, IT strategy and performance in their research (Anderson et al., 1999).

If the resources are not well-integrated with the organization’s strategic objectives, they will not lead to high performance even if the organization poses unique IT resources. Oh and Pinsonneault (Oh and Pinsonneault, 2007) study shows that the worth of a resource can be maximized when it supports the business strategy. However, we should also consider that, not all IT resources are expected to produce considerable strategic value. Oh and Pinsonneault suggests that the interaction between business strategies and IT is directly linked to organizational performance.

Oh and Pinsonneault decomposed the overall alignment measure into three components;

- Cost reduction (e.g., Operational efficiency),
- Quality improvement (e.g., Quality control),
• Revenue growth (e.g., Innovation, marketing, and services)

With their definition, Each component represents the degree of alignment between business strategy (Oh and Pinsonneault, 2007). Management should consider alignment an ongoing process rather than an end outcome. Usually organizational complexities make it difficult for managers to perceive the true consequences of misalignment.

The two conceptual approaches to determine Strategic value of IT are:
  • Resource-centered
  • Contingency-based

These two perspectives are conceptual basis to study the strategic value of information technologies. Many researchers have worked on both of these perspectives. For example (Barney, 1991, Dierickx and Cool, 1989) for the resource-centered view, and (Fry and Smith, 1987) for the contingency-based view.

The resource-centered perspective considers IT to be a strategic resource. When IT combined with other strategic resources appropriately it can directly influence organizational performance (Oh and Pinsonneault, 2007).

The contingency-based perspective suggests that the strategic value of IT must be considered in combination with an organization's strategy. Business strategy and IT strategy should be fitted with each other in this perspectives so it makes difference with regard to another perspective.

Oh and Pinsonneault (Oh and Pinsonneault, 2007) compared two conceptual (resource-centered and contingency-based) and two analytical (linear and nonlinear) approaches. Their study showed that the resource-centered perspective has better ability to predict of IT impact on organization’s profitability. Results of their study indicate that investments in growth-oriented tasks positively affect the firm revenue.

### 3.2 IT Evaluation

In a survey, Anderson (Andresen 2001) showed that 59% of the organizations cannot identify and document the effects of using IT systems. It strongly indicates a need to focus on IT evaluation. Also for the following reasons, the company's IT strategy is regarded as a crucial part of IT evaluation practice; (Hochstrasser and Griffiths, 1991)

  • It will affect the IT investments’ desirability
  • IT evaluation will focus on long-term goals benefits
  • IT evaluation will consider the whole organization instead of individuals
  • Reduction in the risk that local IT investments become mismatched with the future plans of the organization
  • The size of the company is in direct relation whether an organization has a written IT strategy or not.
IT strategy is a guideline for the organization’s IT usage. It should consider the goals of IT usage and roads to achieve these goals (Hochstrasser and Griffiths, 1991). In order to evaluate the impact of IT on the organization's efficiency, it is also important to align IT investments with the organization’s bottom-line business goals (Miller, 1993).

Evaluation of IT investments with respect to its strategic contribution to the firm's efficiency is not possible without an IT strategy. Criteria used in IT evaluation have shifted from “economic benefits” in the investment stage, to user-oriented benefits (Andresen 2001). So in the next part, I will choose an evaluation method and criteria to be in a right path for evaluation of IT effects.

This part is making a base to answer the first and second research question. With naming problems of organization to identify IT, I made a base for naming IT effects on firm-level efficiency in part 6.1. As stated in this part, IT strategy is regarded as a crucial part of IT evaluation practice so I have made a base to study different evaluation methods. In this way, I can conclude that integrated model as the privilege of strategic view between IT evaluation methods, so it is preferred to use the integrated BSC-DEA model.

3.3 Choosing an evaluation method?

Evaluation of costs and benefits of IT systems in an organization shows the business advantage of IT for them. The ultimate aim of improving the IT evaluation practice is to enable organizations to improve the usage of their IT investments and to become more efficient in allocating their resources.

Anderson (Andresen 2001) has worked in his PhD thesis on different types of IT investment from some Danish companies. He has concluded that different methods and factors have influence on the company’s decisions. Based on this reasoning, he has built his framework.

Anderson (Andresen 2001) framework considers the nature of the company, business objectives and reasons for evaluation and its use of IT. It weights these criteria according to their importance, and matches a company’s needs to one of the generic types of evaluation method.

The framework in Andersen thesis (Andresen 2001) only studies IT evaluation methods which meet special requirements. It means that these methods are only for the specific situations. So Andersen’s framework for selecting IT evaluation method may not be useful in another situation, or another company.

There are two major issues in defining an IT evaluation framework; First, Identification of influential parameters for evaluation of IT investments and second, the framework for selection of the best matching IT evaluation method. Anderson (Andresen 2001) consider four steps to identify the best matching IT evaluation method.

1. Select the best matching attribute(s) in the parameters
2. Select the parameters’ weight
3. Combine the parameters’ attributes and the weights
4. Identify the best matching method

The criteria used for evaluating IT investments are shown in figure 1.

Anderson (Andresen 2001) identifies the important parameters on the choice of IT evaluation method as follows:

- Company size
- IT maturity
- IT evaluation practice
- The 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

Anderson identifies these parameters through:

1. A theoretical analysis of how the methods can be characterized
2. The questionnaire survey
3. An empirical investigation of which parameters are influencing the company’s IT evaluation and the choice of method

By analyzing these parameters, three groups are identified to show how IT evaluation methods are chosen. These three groups are Company, IT evaluation and IT investment.

The first group is Company. The parameters of this group are associated with the characteristics of the company that wants to conduct an IT evaluation. Some parameters in this group do not usually change over time so they are Static.

The second group is IT Evaluation. ‘IT Evaluation’ group is associated to the process of IT evaluation. All the parameters in this group are related to how the IT evaluation is completed. These parameters should adjust themselves to the company’s existing IT evaluation so they are dynamic.

The third group of parameters is IT Investment. Third group describes the characteristics of the IT investment that we want to evaluate. The nature of these parameters is also dynamic.

Figure 2 shows groups and their corresponding parameters.
Kuang-Hua (Kuang-Hua, 2005) believes that many organizations have lost the non-financial aspects for assessing the performance. He indicates in his paper that traditional performance indicators have three major drawbacks. First, usual performance indicators only focus on the operational results and they do not pay enough attention to the processes.

When we are designing a strategic efficiency evaluation system, we should consider both financial and nonfinancial indicators. We should also take into consideration the organizational hierarchy effects on the organization's performance. Different levels of the organization have their own unique goals to achieve. Because of these different goals, organizations need different standards and baselines to measure their performance (Kuang-Hua, 2005). (Hoffecker and Goldenberg, 1994) believe that performance assessment system should have both long term and short term objectives.
Using the essence of these parameters, I defined and approach especially in selecting the appropriate parameters for BSC that fits for the IT investment’s situation. In the next chapter, I will explain about Balance scorecards and the meanings behind that.

This part main concern was to answer the second Research question of ‘How can BSC-DEA model help us to better evaluate organization’s efficiency?’ after studying the role of strategic view in IT and IT strategy role in organizations, I studied some crucial factors to be consider in IT evaluation method.

Based on these factors, I argue that BSC-DEA could be a good choice for evaluation of IT in a company. As stated in this part, I have made a base to study different evaluation methods. In this way, I concluded that integrated model as the privilege of strategic view between IT evaluation methods, so it is preferred to use the integrated BSC-DEA model.

4 Balanced scorecards

4.1 BSC as a strategic management tool

Many researchers have criticized that the traditional performance assessment methods are partial. They do not comply with operational strategies. Thus, they lose their strategic managerial and decisional function. They have also criticized the overemphasis on short-term financial results that can cause a bias towards investing in tasks. It can cause the insufficient IT investments with long-term benefit for the organization. It can damage the intangible and intellectual property of organization that usually IT investment produces.

To defeat this difficulty, during the study on the evaluation of organizational performance, Kaplan and Norton (Kaplan and Norton, 1996) introduced the concept of “Balanced Scorecard” (BSC) as the foundation for strategic management system. Accordingly, many other performance assessment methods had been introduced to overcome the shortcomings of traditional performance assessment system. Among them, Balanced Scorecard not only possesses performance assessment function but also the strategic management functions. Therefore, the Balanced Scorecard has the benefit to fill the gap of traditional performance evaluation.

BSC introduces four management processes to join short-term activities with long-term strategic goals (Kuang-Hua, 2005). These processes are:

1. Clarifying visions and reach consensus is the duty of vision transformation.

2. Communication and connection should clarify objectives, and join compensation with performances.

3. Operation planning has several roles; setting goals, unifying strategic motives, distribution of resources, and setting benchmarks.
4. Feedbacks should create and modify visions. It should be a base for facilitating the strategic learning and auditing.

The BSC is a collection of measures, arranged in cards. The measures are related to four major managerial perspectives, and have a comprehensive view of the business. In general, balanced scorecard merges business strategies into a comprehensive management system.

Increasing use of BSC in and various management can be seen in recent researches like: in supply chain integration (Chang, 2009, Bhagwat and Sharma, 2007), R&D projects (Eilat et al., 2008, Asosheh et al., 2010), E-Business (Chang and Graham, 2010), ERP (Zhou and Zhou, 2010), E-commerce (Peide and Zhengwei, 2008), University Performance evaluation (Wu et al., 2011). According to Harvard Business Review, Balanced Scorecard is the most influential managerial concept in 75 years.(Kuang-Hua, 2005)

The BSC presents four other perspectives. BSC merge financial and operational measures. It also focuses both on the short- and long-term objectives of the organization. Traditional financial measures by themselves are inadequate in providing a complete and useful overview of organizational performance. In this way, we can be ensured to have a more balanced evaluation of the organization(Eilat et al., 2008).

Four perspectives of Balance Scorecard are:

- Financial perspective
- Customer perspective
- Internal business process, perspective
- Learning and growth perspective

The main question of each perspective is shown in figure 3.

![Figure 3 Four perspectives of BSC](image-url)
4.1.1 The financial perspective

The financial perspective is concerned with the contribution of the IT investment in terms of money. It reflects the issues like the budget, cost, profitability, maintaining liquidity, cash flow, both short term and long-term monitory objectives, maximizing wealth of shareholders and etc. The financial perspective is the center of objectives and measures in the other BSC perspectives. The other perspectives in BSC should have cause-and-effect relationship to improve financial performance (Kaplan and Norton, 1996).

This perspective links organization to its shareholders. The main question in this perspective is; how do we look to our shareholders and those with a financial interest in the organization? (Bhagwat and Sharma, 2007)

The measures in this perspective show that execution organization strategy, has improved the financial results. Financial perspective’s measures execute the organization's financial strategy in detail.

4.1.2 The customer perspective

This is the second perspective that considers organization’s customers. Customers are a crucial factor for financial success. By buying products and services, they generate revenue for the organization. According to Bhagwat and Sharma ,The question in this perspective is ‘How do our customers perceive us in term of products, services, relationships and value-added activities?’(Bhagwat and Sharma, 2007)

For choosing Customer perspective’s measures, organizations must specify the target customers first. Then the organization should evaluate each IT proposal in terms of value that it can create for the customer?

IT investment provides responsiveness, timeliness, quality, and service that the customer needs. Customer perspective includes indicators like customer surveys, complaints, focus groups, delivery reports, etc. We should ask ourselves “from the point of view of the customer, how successful are the IT investment?” According to Eilat (Eilat et al., 2008),Time, quality, performance, treating the customer and customer satisfaction are the issues for evaluation IT effects in costumer perspective.

4.1.3 The internal-business processes perspective

This perspective studies contribution of the IT investment to the main competencies of an organization. It specifies the level of support that IT investment provides for the organization's mission and strategic goals. The top management should already determine the strategic view of the organization.
When fit of Strategy and IT objective is poor, IT investment proposal should be rejected or the strategy must be revised. ‘fit level’ must influence the total measure of the IT investment ’s attractiveness.(Eilat et al., 2008)

The question in this perspective is ‘what should the organization excel at?’ (Bhagwat and Sharma, 2007). The organization must excel at the key processes to add value for customers and shareholders. In order to expand core capacities, the organization must establish specific measures.

Measures of internal processes have the greatest impact on customer satisfaction and organization’s financial situation. Management of the organization should decide what processes and competencies the organization must excel at. In order to do that, management should indicate the appropriate measures for each of these processes and competencies.(Bhagwat and Sharma, 2007)

### 4.1.4 The learning and growth perspective

In today's business competitive environment, organizations try to improve their performance to have power in the competition. This requires capabilities to deliver value to customers and shareholders. The measures in the Learning and Growth perspective have the role of enablers for another three perspectives. This perspective is the groundwork that entire Balanced Scorecard is built on.

When the evaluation of organization efficiency only considers short-term financial results, it is difficult to carry on investments to improve the human resources capability. Hence, learning and growth perspective looks at the long-term impact of the IT investment for growth and improvement of an organization. The measures determines whether the IT investment is a platform for growth or not. These measures usually consider durability of IT effects.(Eilat et al., 2008)

The objective of this perspective is to supply the infrastructure and to enable the objectives of other three perspectives. The main question in this perspective is: “how will we continue to improve and create future value for our stakeholders, To achieve our future vision?”(Bhagwat and Sharma, 2007)

### 4.2 BSC for evaluating IT Investment Proposals

BSC is useful in evaluation of IT investment proposals. BSC can evaluate achievement of ongoing IT investment projects together with finished IT projects. I have described the usage of BSC in different IT investment phases below.

- During the selection phase,
When we evaluate IT investment proposals, the BSC simplifies and translates the vision and strategy of the organization in order to determine the appropriate criteria for proposal attractiveness. Therefore, Measures should represent ‘what is expected from these IT investments in return’.

- **In the planning phase,**

  BSC sets targets and aligns IT investments with the organizational strategy. BSC also allocates resources within and among IT related tasks in the organization.

- **In the execution phase,**

  BSC provides relative measures of performance. It evaluates the value of the IT investment by considering changing circumstances and priorities of the organization. The measures are a combination of forward-looking measures for the future tasks and backward-looking measures for what has been done already.

- **Finally, at the closing phase,**

  BSC identifies best practices, and advances continuous learning for the organization in at the closing phase of IT investment.

### 4.3 Creation of BSC

For evaluation of IT investment proposals, or achievement of ongoing IT investments, first we should determine appropriate criteria.

Quantitative measures in BSC can give management a comprehensive view of the organization's goals both in its financial and operational performance. Thus, organization’s progress toward meeting its goal becomes transparent. This transparency helps managers drive the organization on the planned road for its development (Rickards, 2003).

Kaplan and Norton (Kaplan and Norton, 1996) state that BSC turned business strategies into measurable indicators. To create measurement indicators that are closely connected with business strategies, management must consider the following three factors:

- Cause and effect
- Outcome and driver
- Financial connection

In order to consider ‘Cause and effect’ factor, we should use “What if” to design performance indicators and to consider the communication between the indicators.
A cause-effect association between the three aspects and financial aspect can help the organization accomplish its goal more easily (Kuang-Hua, 2005). So lastly, in financial effect, we try to connect the indicators from all the other perspectives (the customer aspect, organizational process aspect, and learning and growth) with financial goals as inputs and outputs. It is a base to do the second step of BSC-DEA model, which is DEA calculation of efficiencies.

Kuang-Hua (Kuang-Hua, 2005) separates the performance indicators into two categories: the leading indicators and the lag behind indicators. In the efficiency assessment process, we have a general result as the outcome, but in details, we should be able to identify differences amongst performance indicators.

Challenges in creation and using a BSC based on (Rickards, 2003) are:

First, it is necessary to decide how many units within a given organization require BSC indicators. Observation suggests that organizations typically allow each strategic business unit to have its own BSC.

The second challenge is the number of variables reported in each area of a BSC.

### 4.4 Implementing a Balanced Scorecard

The implementation of Balanced Scorecard is a several step process. To set the baselines for goals, BSC requires that we have a set of performance indicators. These performance measures should be in a well-made organizational system. Moreover, for making the performance indicators, we should consider the following two problems. (Kuang-Hua, 2005)

1. First, we have to consider the limitation of resources. Resources should be used to their greatest extent.

2. Second, we must reach an agreement with targeted work teams while we are trying to set the performance indicators. Thus, these work teams should work as expected in the agreements.

We should consider the criteria that managers feel they are most important, and we should check the feasibility to provide information and the availability of information. It is also important that data be complete and not be redundant. These information should be connected to the short- and long-term objectives of the organization (Eilat et al., 2008). To determine the criteria set, I used a model based on the BSC approach.
5 Need for integration of BSC with DEA

5.1 BSC weak points and need to improve

While we are working with the Balanced Scorecard, we should be able to evaluate the efficiency of an organization. Business performance is usually unclear and vague. Data Envelopment Analysis Method (DEA) can generate the objective performance indicators (Kuang-Hua, 2005).

Therefore, there are four main reasons that indicate the need for BSC for a complementary tool.

1. One of the challenges in BSC is having the baseline or benchmark which performance is measured against. Evaluation is impossible without a baseline or benchmark. First, a baseline for evaluation should be determined and then we should do the evaluation against the baseline. However, baselines and benchmarks are hard to determine and can be ambiguous. Because DEA is based on relative comparison, the DMUs are evaluated against each other. By combining the BSC with DEA we can answer important challenge of BSC, namely, the need to determine baseline and benchmark (Eilat et al., 2008).

2. Furthermore, BSC does not have a mathematical model or a weighting scheme. Therefore, it is difficult to make comparisons within and among the organizations. As a result, the inefficient use of resources may be unrecognized (Banker et al., 2005, Chien-Ta and Dauw-Song, 2004, Kuang-Hua, 2005). Rickards (Rickards, 2003) argues that DEA is suitable for measuring the efficiency based on the BSC indicators. The efficiency frontier of DEA can be used to calculate the efficiency of DMUs. The slacks can be used as the organization's inefficiency to solve the recognition of inefficiencies in BSC.

3. BSC confronts managers with an extraordinarily complex optimization problem because of BSC has complexity and the interrelated indicators. This complexity also rises from the large number of variables. For example big organizations should try to track hundreds of measures in BSC (Rickards, 2007). Fletcher and Smith (Fletcher and Smith, 2004) state that BSC lacks a single index for accountability. BSC does not provide one comprehensive index to summarize the interaction between these measures of performance.

4. Lack of a common scale of measurement causes more complexity. Moreover, in BSC, we may have dimensionless ratios and index numbers. Luckily, data envelopment analysis (DEA) can help us to deal with this kind of complexity (Rickards, 2007).

DEA can be a helpful tool to deal with all of these problems. In the next chapter, I will explain the definition of efficiency measurement and Data envelopment Analysis.
6 Technical efficiency

6.1 Definition
A firm utilizes different kinds of resources (inputs) and produces goods/services (outputs). The inputs are usually capital, labor, materials, etc. Production process is the transformation of inputs into outputs (Shao and Lin, 2002). The production frontier describes the relationship between inputs and outputs. It specifies the maximum achievable output by having a combination of inputs.

Technical inefficiency is the distance between the maximum output (or the production frontier) and the actual output. Thus, a firm is technically inefficient when it is below the frontier and is technically efficient if it operates on the production frontier.

Here it is useful to distinguish between technical efficiency and productivity; Technical efficiency is concerned with having more output and production by using input resources with regard to production technology. Technical efficiency concentrates whether on the output part or the input part of a production process. Thus, an indicator of technical efficiency can be actual output vs. Expected output (given some input amounts) or resources (inputs) actually used versus resources expected to be used (for making a certain level of output).

Productivity describes the effective use of overall inputs, without implying any production technology. Shao and Lin (Shao and Lin, 2002) describe productivity as evaluation of the production process outputs against what are consumed to produce them. Productivity growth is then measured as a set of successive indices that compare outputs to inputs.

Connection between technical efficiency and productivity is defined as: “productivity growth is a composite index of the change in technical efficiency and the shift in the production frontiers” (Banker et al., 2005, Emrouznejad, 2005)

\[
\text{Productivity growth} = \text{technical efficiency change} \times \text{technical change}
\]

Therefore, technical efficiency is an important component to determine firm productivity. Technical efficiency is also an important economic measure to evaluate organizational performance. Technical efficiency is directly related to, but different from, productivity. Productivity has been investigated broadly from the perspective of IT business value e.g. (Mukhopadhyay et al., 1997, Cooper et al., 2007).
There are two approaches to measuring technical efficiency:

1. Parametric

2. Nonparametric

The parametric approach assumes a functional form for the production frontier. Technical efficiency scores in the parametric approach are absolute technical efficiencies because the parametric production frontier is the real frontier. There is always the possibility of misspecification of a functional form in the parametric production frontier. Researchers regard it as one potential drawback of parametric approach.

Nonparametric production frontiers deal with mathematical programming. It does not assume any functional form. For calculating the efficiency, the data points are compared with each other. The most efficient observations construct the piece-wise linear convex frontier. As a result, nonparametric production frontiers measure relative technical efficiency. (Cooper et al., 2007)

Figure 4 illustrates a piece-wise linear convex isoquant. Suppose that there are two inputs X1 and X2 which production process uses to produce output Y and also there are five observations; A, B, C, D and E.

![Figure 4 Piece-wise linear convex isoquant and technical efficiency](image_url)
B and C are the most efficient ones because they have utilized the least input combinations to produce the same level of output. Based on this reasoning, they establish the piece-wise linear convex isoquant frontier SS.

However, A is technically inefficient. Point A wants to move closer to the frontier SS to gain its ideal position. Therefore, point F on the frontier SS becomes the ideal target for firm A. The distance AF can be treated as its technical inefficiency. With this perspective, the ratio of AF/AO represent technical inefficiency and represent technical efficiency is FO/AO (1 - AF/AO).

Every score of efficiency has the range of 0 to 1. A higher score indicates a higher technical efficiency. Because B and C both lie on the nonparametric production frontier, they have perfect technical efficiency scores.

The ratio measures are completely ‘unit independent’ so the change in measurement units does not affect the efficiency scores. This is one of the great merits of using nonparametric method.

### 6.2 IT effects on Technical efficiency

Azadeh and Keramati (Azadeh et al., 2009) studied the relationship between IT and organizational performance. They have concluded that the IT status and company’s performance have a linear relationship. Wu (Wu, 2006) has also detected the impact of IT on firm performance, with using Data Envelopment Analysis (DEA) and Decision Trees (DTs).

Shao and Lin (Shao and Lin, 2002) presented an approach to investigating the effects of IT on firm’s technical efficiency through a two-stage analytical study with a firm-level data set.

All of these effects are the answers to first research question of ‘What are IT-effects on Firm-level efficiency?’

In the first stage of Shao and Lin’s approach, data envelopment analysis (DEA) measures a firm’s technical efficiency scores. DEA constructs a nonparametric production frontier and measures the scores of technical efficiency.

In the second stage, Shao and Lin’s have used the Tobit model (Amemiya and Associates, 1982) to regress the efficiency scores for the firm’s IT investments. Tobit model treats efficiency scores as a dependent variable and regressed upon the IT investments to examine whether IT has a positive effect on technical efficiency or not.

Banker et al. (Banker et al., 1990) also analyzed a chain of fast food restaurants to Measure the benefits of information technology in operational efficiency. In this thesis, I have chosen the Data envelopment Analysis method to evaluate effects of IT on the organization's technical efficiency. In the next chapter, I present DEA method and its definition.
7 DATA ENVELOPMENT ANALYSIS

7.1 Definition

There are many literatures about optimization in the selection process and allocation of important strategic resources. For example, they study: substantial long-term commitments (Santhanam and Kyparisis, 1995), assessment of bank branch performance (Camanho and Dyson, 2005), selection of flexible manufacturing system (Liu, 2008), examining bank efficiency (Chen et al., 2005) and measuring the efficiency of higher education institutions (Johnes, 2006, Johnes and Yu, 2008).

Other researchers have also studied issues like: analyzing organization’s financial statements (Edirisinghe and Zhang, 2007), measuring the efficiency of organizational investments in information technology (Shafer and Byrd, 2000, Shao and Lin, 2002) and implementation of the BSC in measuring the performance of R&D activities (García-Valderrama et al., 2009, Bremser and Barsky, 2004).

Charnes, Cooper, and Rhodes (Charnes et al., 1978) were the first researchers who introduced DEA in 1978. They called their first model ‘CCR’ that is abbreviation of their first names. They developed a basic DEA model to determine either input or output efficiency. Banker, Charnes, and Cooper (Banker et al., 1984) then developed another model named ‘BCC’. This alternative model can handle flexible cases.

DEA has gained too much attention by business sectors and academy researchers. Because DEA is a simple method. In addition, DEA has successful application in the case studies. Evaluation of data warehouse operations (Mannino et al., 2008), Selection of the best vendors (Liu, 2008) are samples of using DEA in various Case studies. Evaluating multi-criteria systems and showing targets for improvement, show the usefulness of DEA (Seiford, 1996).

DEA is a mathematical programming technique, which constructs a linear program to identify the nonparametric production frontier and measures DMU’s technical efficiency. DEA calculates the relative efficiency of DMUs based on observed inputs and outputs. These inputs and outputs are usually expressed in different types of metrics.

DEA is broadly recognized technique that evaluates the efficiencies of decision-making units (DMUs). In practice, DMUs can be like branch stores, organization divisions, business offices, different manufacturing sites, work teams, and so forth. Each DMU serves as basis for comparison and define benchmarks for the other DMUs (Cooper et al., 2007)
DEA utilizes inputs to produce outputs. Typically, DEA considers the system as a black box. In measuring the efficiency, we only consider inputs and outputs of this black box. Figure 5 shows this view.

![Figure 5 DEA view of a system](image)

DEA does not consider performance of the system's components that are interacting with each other inside the system. Wang and Gopal (Wang et al., 1997) have been criticizing this view because of direct relation of IT to firm-level performance. Shao and Lin (Shao and Lin, 2002) have concluded in their studies that organization’s IT spending has a positive effect on the technical efficiency of the production process.

As a simple view, DEA is (Charnes et al., 1978):

\[
\text{Efficiency} = \frac{\text{weighted sum of Outputs}}{\text{weighted sum of inputs}}
\]

Therefore, efficiency indicator of a particular DMU depends on the relationship between the weighted inputs and the weighted outputs. The original DEA model selects weights for each DMU to maximize the efficiency. With assessing all the DMUs, DEA makes an “efficiency frontier” and identifies each DUM’s relative efficiency

Coo et al. (Cooper et al., 2007) studied of U.S. Army Recruiting Centers. They focused on value-added activities of an organization. They concluded that identification of all value added activities is not required. They specified the production processes involving IT and then considered the rest of the system as a black box for analysis of performance.

Wang and Gopal (Wang et al., 1997) argue that IT directly impacts certain intermediate output variables. These output variables have a big influence on the efficiency. They consider that the efficiency of the intermediate processes affects the overall efficiency, and vice versa. Therefore, they propose a multi stage DEA.

However, the connection between the system efficiency and process efficiencies is not fully revealed (Kao and Hwang, 2008). Some literature have studied this issue with a hybrid model using DEA (Wu, 2009), neural network and DEA (Emrouznejad and Shale, 2009) and networked DEA methods (Färe and Grosskopf, 2000, Kao and Hwang, 2008).

There are two ways for calculating and analysis of DEA.
1. Input-oriented analysis
2. Output-oriented analysis

### 7.2 Input-oriented analysis

In the input-oriented analysis, the model tries to maximize the sum of weighted outputs. It will consider inputs equal to one.

### 7.3 Output-oriented analysis

An output-oriented analysis does the reverse: the model sets the output equal to one and it tries to minimize the sum of the weighted inputs.

### 7.4 Return to scale:

In the ‘constant returns to scale’ an increase of inputs in a DMU’s, leads to a proportional increase in its outputs.

However, in the ‘variable returns to scale’, a change in the input leads to a disproportional change of output.

### 7.5 CCR model

According to Cooper (Cooper et al., 2007) for any specific organization of j, the CCR model with ‘constant returns to scale’ can be formulated as follows to obtain its score of technical efficiency (where ‘n’ is the number of DMUs and ‘K’ is the number of inputs and ‘M’ is the number of outputs)

\[
H_j = \max \sum_{r=1}^{m} u_r y_{rj} / \sum_{i=1}^{k} v_i x_{ij}
\]

\[1\]
\[
\sum_{r=1}^{m} u_r y_{rj} + \sum_{i=1}^{n} v_i x_{ij} = 1 \quad \forall j
\]

\[u_r, v_i \geq \varepsilon\]

- \(u_r\) = Weight given to output r
- \(y_{rj}\) = Amount of output r produced by DMU j
- \(v_i\) = Weight given to input i
- \(x_{ij}\) = Amount of input i consumed by DMU j

The u's and v's are variables and they should be greater than or equal to a small positive quantity \(\varepsilon\) because we try to avoid to ignore any input or output in determining the efficiency (Emrouznejad, 1995-2001). Efficiency of all units being also should be less or equal to 1.

### 7.6 CCR- Dual Model

In linear programming (LP), we can formulate a partner LP with employing the same data. The solution to either the original LP or the partner (the dual) gives the same information about the problem. It is the same in DEA (Emrouznejad, 1995-2001).

\[
\min \quad \theta_j
\]

\[
S.T: \quad -y_{rj} + \sum_{j=1}^{m} \lambda_{rj} y_{rj} \geq 0 \quad r = 1, 2, \ldots, m
\]

\[
\theta_j x_{ij} - \sum_{j=1}^{n} \lambda_{rj} x_{ij} \geq 0 \quad r = 1, 2, \ldots, k
\]

\(\theta_j\) is the efficiency of DMUj and it is the same as the basic CCR model. In the theory of linear programming, the results from the dual model are the same.

In linear programming, usually the more constraints a model has, the more difficult it is to solve. As we see, the primal model has more constraints than its own dual model. Hence, it is usual to solve the dual DEA model rather than the primal.
7.7 Other DEA models

Banker, Charnes, and Cooper (Banker et al., 1984) developed another model named ‘BCC’. BCC models have the variable return to scale. BCC estimates technical efficiency for a given observation and then evaluates whether increasing, constant, or decreasing returns to scale would improve the efficiency.

**Multiplicative models** do not have the assumption of linearity in DEA. They have the possibility to assume that production relationship has a logarithmic-linear or a Cobb-Douglas function (Burkle, 1997). These models specify the form of the production function and stipulate a priori a particular relationship among the variables. Therefore, they do not have great advantages of the nonparametric methods anymore. That is why Multiplicative models have little use in practice.

**Additive models** (expanded additive models) study the DEA with the CCR-ratio model’s analyses of inefficiency. They combine the results of such analyses with the economic concept of Pareto optimality. Additive models maximize the sum of all input and output slacks without making use of the non-Archimedean quantity (Cooper et al., 2007). Additive model results are equivalent to CCR-ratio model, but it offers other points of comparison.

Table 1 shows the brief review of these models:

<table>
<thead>
<tr>
<th>Model</th>
<th>Year developed</th>
<th>Orientation of the weighting</th>
<th>Returns to scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCR ratio</td>
<td>1978</td>
<td>Input or output</td>
<td>Constant</td>
</tr>
<tr>
<td>Multiplicative</td>
<td>1982/1983</td>
<td>Input and output</td>
<td>Constant or variable</td>
</tr>
<tr>
<td>BCC</td>
<td>1984</td>
<td>Input or output</td>
<td>Variable</td>
</tr>
<tr>
<td>Additive</td>
<td>1985/1987</td>
<td>Input and output</td>
<td>Constant or variable</td>
</tr>
</tbody>
</table>

Table 1 various DEA models  (Cooper et al., 2007)

7.8 Controlling the weights in DEA

However, in reality unconstrained weights are unacceptable (Roll, 1993). Large differences in the weight values for different DMUs are also an important issue that we should consider. Therefore, researches developed restricted DEA approaches to have control over the weights in DEA. A general way to control factor weights is the cone-ratio (CR) method (Charnes et al., 1989). It uses the original DEA formulation (Charnes et al., 1978) and requires the values for input and output weights to be restricted regarding the given closed cones.

Another approach is the assurance region (AR) principle (Thompson et al., 1990). In the assurance region, the weight of one output or input is used as a basis to compare weights of other outputs or inputs. Other researchers have also published some other methods for controlling the
weights in DEA, for example (Roll, 1993), (Dyson and Thanassoulis, 1988) and (Roll et al., 1991).

### 7.9 Choosing the appropriate DEA model

In order to choose an appropriate DEA model, we should first consider whether the observed DMUs are subject to scalar effects or not. We should answer this question: does a growing DMU, which constantly produces outputs, also need proportionally more input?

A simple way to answer this question is to examine the correlation between inputs and outputs graphically. Figure 6 shows hypothetical relationship between a hypothetical output and input. As we see, the relationship is nonlinear. It displays decreasing returns to scale. So we assume variable returns to scale for this model, hence we choose the BCC model for a DEA.

![Figure 6 A nonlinear input/output correlations](image)

Wang and Gopal (Wang et al., 1997) argue that IT directly impacts certain intermediate output variables which have a big influence on the efficiency. They consider that the efficiency of the intermediate processes affects the overall efficiency and vice versa. Therefore, they propose a multi stage DEA for it.

However, the connection between the system efficiency and process efficiencies is not fully revealed (Kao and Hwang, 2008). Some literature have studied this issue with a hybrid model using DEA (Wu, 2009), neural network and DEA (Emrouznejad and Shale, 2009) and networked DEA methods (Färe and Grosskopf, 2000, Kao and Hwang, 2008), and.

Coo et al. (Cooper et al., 2007) had the same manner in a study of U.S. Army Recruiting Centers. They focused on value-added activities of an organization. They concluded that identification of all value added activities are not required. They specified the production
processes involving IT and then considered the rest of the system as a black box for analysis the efficiency.

In a general remark, choosing the appropriate DEA model depends on each situation that evaluation is carried on. The management view of the system is also very important to decide which DEA model should be used. For example if we see the system like a black box, simple DEA model like CCR or BCC is appropriate. However, if we see the system like two stage boxes, it is better to evaluate the efficiency with the specific CCR model like the one in (Shao and Lin, 2002).

7.10 DEA and marginal impacts

Identification of marginal impacts of IT is an important issue in evaluating of performance. Calculating the rate of change in efficiency with change in the IT-related input and identifying the contribution of a specific input in producing outputs is problematic.

This part addresses the third research question of ‘What are the marginal effects of IT on organization’s efficiency?’

DEA measures technical efficiency so if a DMU is efficient, it means that it is not possible to have the same amount of outputs by using fewer inputs. The technical efficiency does not specify the contribution of a specific input in the efficiency evaluation.

Farrell (Farrell, 1957) suggests a two-stage approach for solving this problem. He states that the “weights” calculated in the dual formulation of DEA can indicate the importance of the input and the output variables. The general approach to identify importance of inputs is to compare their weights in DEA (Charnes et al., 1985).

Banker and Thrall (Banker and Thrall, 1992) propose that there could be alternative optimal solutions for every DMUs with an efficiency of 1. Another problem is choosing set of weights for interpretation. Wang and Gopal (Wang et al., 1997) provide a meticulous formulation to identify the effect of a set of input on a set of output.

Therefore, an important marginal impact of DEA is the ability to identify improvement potentials with Slack’s analysis.

7.10.1 Improvement potential: slacks

By comparing technical efficiency of the different DMUs, we can identify overconsumption of inputs or underproduction of outputs. Inefficiencies are named “slacks”. In another view, slacks show improvement potentials.
For example, Figure 7 shows six DMUs. Each DMU uses two inputs to produce two outputs. DMUs 5 and 6 are at points of Y and Z. The difference between Y and Z shows the amount of slack and the potential amount of improvement.

In other words, DMU 6 at point Z can operate more efficiently and increases output 1 until it reaches the efficiency of DMU 5 at point Y and there is no need to reduce in its production of output 2. As a result, we can say that DMU 5 “dominates” DMU 6.

In practice, we should check whether it has worth it to use the available improvement potential or not. For interpretation of observed inefficiencies, we should always consider slacks relative to dominant points (Rickards, 2003).

7.11 DEA advantages

DEA as an empirical tool in studying IT impacts on performance has many advantages like:

1. DEA permits to analyze multiple inputs and output factors simultaneously. This ability is very helpful in real-world management situations because there are usually multiple, multidimensional inputs and outputs. From this perspective, DEA is better in comparison with traditional approaches that can only deal with multiple inputs and a single output.
DEA measures the efficiency without transaction or conversion through any prior function (ChangSu-Chao et al., 2005). Managers can use DEA results to improve and to increase their competitiveness.

2. DEA solves an optimization problem and gains its weights result. Hence, DEA is only dependent on the empirical observations. This fact gives the DEA a great advantage over usual optimization procedures.

3. There is no need to normalize IT investments data. When we want to use an econometric approach to explain something like for the “level of IT use or “size factor” in a model, normalization is necessary. (Wang et al., 1997)

4. DEA is a non-parametric approach so it does not need to have an explicit functional form to relate inputs to outputs. We know using the parametric methods and speculating the functional form of production can significantly influence the results (Forsund and Hjalmarsson, 1979). Therefore, DEA is very useful when we are using IT in an organization without prior detailed knowledge Impact of IT on that organization.

5. Even when we use a parametric approach to evaluate IT impacts, DEA eliminate inefficient observations from the sample. DEA characterize the scaling properties of the production operation process. It reduces the bias in parameter estimation.
8  Integrated BSC-DEA model

8.1  BSC-DEA concept
This thesis integrates the balanced scorecard (BSC) and data envelopment analysis (DEA) to make a relational efficiency evaluation model. In the integrated DEA-BSC model, the input and output measures are grouped in cards, which are related to BSC’s perspectives. The proposed model is based on DEA, which quantifies the qualitative concepts embedded in the BSC approach. The contribution of the presented model is both conceptual—the integration.

Figure 8 gives a general view of integrated BSC-DEA model.

According to Cooper (Cooper et al., 1999), integrated DEA–BSC model is trying to accomplish:

1. Achieving strategic objectives (effectiveness goal);
2. Optimizing the usage of resources to generate desired outputs (efficiency goal)
3. Balance between different aspects of the organization (balance goal).

4. Obtaining Cause and Effect in Perspectives

Najafi and his team workers (Najafi et al., 2009) proposed a similar model. With efficiency decomposition, they identified the inefficient operations. They used six banking branch’s data for their illustration.

Shafer and Byrd (Shafer and Byrd, 2000) developed a framework for measuring efficiency of organization’s investment in information technology. They used over 200 large organization’s data in DEA model to show their framework.

Specific DEA models for technology selection in R&D projects were proposed first by (Stewart, 2001). Stewart considered Projects as “mini-organizations” in a BSC’s perspectives, same as their parent organizations. Using Balanced Scorecards for R&D project evaluation have been developed by (Eilat et al., 2008), (Oral et al., 1991), (Baker and Talluri, 1997) and (Khouja, 1995) since then. Sowlati (Sowlati et al., 2005) also proposed a DEA model for prioritizing IS projects.

Eilat and Golani (Eilat et al., 2008) studied the BSC into the DEA model through balance constraints. Different from traditional DEA’s weight restriction techniques which restrict the weight flexibility of the individual weights, Eilat and Golani (Eilat et al., 2008) considered “importance” attached to groups of measures. They applied their method to a hierarchical balance structure.

Furthermore, ChangSu-Chao (ChangSu-Chao et al., 2005) had applied DEA into the BSC to measure performance efficiency of hotels in Taiwan and Vietnam. Their results studied efficiency frontiers and benchmarking partners of each hotel. They also identified the ideal input amount and the slack of every hotel. Here in this thesis, I have summarized all the related literature and I have developed them into IT investments field.

8.2 Measurement processes of BSC-DEA

With the help of Najafi paper (Najafi et al., 2009), I have considered four steps for the processes of measurement and performance rating in this thesis:

1. The identification of organization (Creation of appropriate BSC) is the first step. In this step, organization’s strategies are identified by using BSC. Then we design the measurements in every perspective. The measurements should be in balance and with different perspectives.

2. Efficiency rating is the second step. The measurements created by BSC will be divided into two groups of inputs and outputs to be used in DEA model. Then we use DEA whether in a horizontal evaluation (during the time period) and, or vertical evaluation (in comparison with similar units in the chronological period).
3. Modification and Improvement is the third step. Having the results of DEA, we identify the potential for modification and improvement.

4. Setting the benchmarks is the final step. DEA determines the measurement goals and places them as benchmarks for the next performance evaluation.

If the organization achieves the determined goals, it will be efficient. In the next periods, the organization’s situation is compared with the expected conditions of the previous period. In this comparison, new efficiency goals will be determined (Najafi et al., 2009).

### 8.3 The BSC template

In this thesis, I propose a BSC model to support the evaluation process. The BSC can be a useful tool to translate and clarify strategy of the organization. BSC sets appropriate criteria for an IT investment proposal’s attractiveness. This model consists of two hierarchical levels: the cards and the measures. Figure 9 shows the desired BSC model.

![Figure 9 BSC's perspectives and measures](image)

The model includes four cards (perspectives). Each card has some measures that we regard them as outputs or input. In the next part, I present the complete table with measures in detail.
8.3.1 The objective of the BSC for IT Investment

In general, IT is expected to enhance the organization’s technical efficiency. Most of economics researchers believe that technical efficiency and capital intensity commonly are positively correlated (White, 1978).

Shao and Lin (Shao and Lin, 2002) determined the correlation between IT spending and technical efficiency. They have presented statistical evidence that IT investment has a positive total effect on the organization’s technical efficiency.

Because IT gives services to other parts of an organization, it can be considered as an input to a number of value-added activities (Wang et al., 1997). Wang evaluates impact of IT on the organization's performance by tracking how the IT budget is allocated for different value-added activities for a long period.

Use of IT investment as a measure for evaluating IT investment’s effect may be inadequate because it indicates how many companies are paying and not necessarily how much they are using (Harris and Katz, 1989, Smith and McKeen, 1993). Based on this view, in this thesis I proposed approach to define evaluation criteria to define IT effects on organization performance. In this step, a decision group is asked to develop a set of criteria by considering IT Investment effect on an organization's perspective. This group includes several specialists in the field of IT management and top management who define the organization's strategy.

These criteria should capture all aspects of organization that IT affects. After defining criteria, experts are asked to calculate and to estimate numerical values of them with respect to IT effects. The main output of this step is a table that includes all alternatives and their numerical data.

García-Valderrama (García-Valderrama et al., 2009) has related four perspectives of the BSC by means of DEA. He used the scale developed by (García-Valderrama and Mulero-Mendigorri, 2005) for measuring the effectiveness of R&D activities.

This thesis propose a model according to García-Valderrama’s work (García-Valderrama et al., 2009) to analyze efficiency of organizations, focusing on IT investment’s effect.

Figure 10 shows a general view about BSC’s indicators that I have selected.
Table 2 presents BSC indicators, with their definition. It also includes the questionnaire items that one should ask to define measures for each indicator.
<table>
<thead>
<tr>
<th>Dimension</th>
<th>Measures (Indicators)</th>
<th>Definition</th>
<th>Questionnaire items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial perspective</td>
<td>IT Investment</td>
<td>The amount of money which the organization wants to invest</td>
<td>Estimate the amount of investment in IT</td>
</tr>
<tr>
<td></td>
<td>Discounted cash flow</td>
<td>All cash flows are estimated to their present values (PVs)</td>
<td>Estimate the 3 years cumulative cash flow in dollars (millions)</td>
</tr>
<tr>
<td></td>
<td>Earned value</td>
<td>Earned Value shows the amount of budget and time spent, with regard to the amount of work done so far.</td>
<td>Estimate the amount of Earned value of IT investment’s effects</td>
</tr>
<tr>
<td>Success in the achievement of financial results due to the IT Investment results</td>
<td></td>
<td>Measurement of the achievement of the financial objectives in terms of increased profits and financial profitability</td>
<td>Estimate the increase of profits in the last 3 years derived from the results from IT Investment</td>
</tr>
<tr>
<td>Customers perspective</td>
<td>Customer focus group feedback</td>
<td>Customer focus group is a form of qualitative research in which a group of costumers are asked about their perceptions, opinions and attitudes towards organization</td>
<td>To what degree do the organization need the feedback of the costumer in effect of IT investment</td>
</tr>
<tr>
<td></td>
<td>Customer satisfaction index</td>
<td>Customer Satisfaction Index is an economic indicator that measures the satisfaction of consumers</td>
<td>Estimate the degree of customer satisfaction after IT investment is done</td>
</tr>
<tr>
<td></td>
<td>Complaints</td>
<td>Complaints from all kinds of relations in organization; costumer, other departments and …</td>
<td>Number of complaints after IT investment is done</td>
</tr>
<tr>
<td></td>
<td>Marketing and commercial success due to the application of the IT Investment</td>
<td>Measurement of the achievement of the objectives of the company in terms of sales revenue, market share and customer satisfaction, due to the application of IT Investment</td>
<td>To what extent has customer satisfaction increased due to the application of IT Investment?</td>
</tr>
<tr>
<td>Internal processes perspective</td>
<td>Congruence of the organization's strategy and its IT Investment objectives</td>
<td>Measurement of the degree of match or consistency between the IT Investment objectives and the IT activities, and the current reality of the company and its business situation</td>
<td>How do you rate the effectiveness of the process of planning the IT Investment</td>
</tr>
<tr>
<td></td>
<td>Importance of IT investment</td>
<td>Evaluation the impact of IT investment’s success of the organization strategy, profit. And …</td>
<td>Evaluating whether it is difficult for an organization to recover if investment is unsuccessful or the success of the organization's strategy depends on this Investment</td>
</tr>
<tr>
<td></td>
<td>Match between the IT Investment budget and the objectives</td>
<td>Measurement of success in setting realistic IT budgets in accordance with specific objectives for the IT department</td>
<td>How do you rate the problems faced by the IT department in reaching the objectives set in the plans and budgets of the department?</td>
</tr>
<tr>
<td></td>
<td>The existence of Manuals of procedures for IT activities</td>
<td>Set routines for formalized IT activities in the responsible department</td>
<td>Does the organization have manuals of procedures for IT activities?</td>
</tr>
<tr>
<td>Internal processes perspective (Cont...)</td>
<td>Fluidity of information flow between departments</td>
<td>Degree of communication between the IT responsible department and the other departments of the organization</td>
<td>How well are the IT investment objectives and activities communicated to the IT personnel, and to the personnel of the rest of the company?</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>-----------------------------------------------</td>
<td>---------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Coordination between IT, production and marketing</td>
<td>Measurement of the degree of coordination between the activities undertaken in the IT responsible department and those undertaken in the departments of marketing and production</td>
<td>How do you rate the coordination between the activities undertaken in the IT department and those undertaken in the marketing and production departments?</td>
<td></td>
</tr>
<tr>
<td>Degree of success in keeping costs to budget</td>
<td>Measurement of the problems in implementing new activities proposed by the IT responsible department</td>
<td>How difficult is it for the IT responsible department to keep within its budget?</td>
<td></td>
</tr>
<tr>
<td>General quality of work undertaken by IT investment</td>
<td>Measurement of the degree to which quality parameters in IT activities are achieved. Compliance with quality standards on cost levels in the IT department, parameters on research results, time, etc.</td>
<td>To what extent parameters have been established for measuring quality in IT activities. To what extent such quality parameters are achieved.</td>
<td></td>
</tr>
<tr>
<td>Effort of IT investment</td>
<td>The company allocates funds to cover activities related to IT by reference to the average of previous years.</td>
<td>What is the percentage of increase in annual expenditure on IT investment in the last 3 years, compared with the average of previous years?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>The company allocates investments in IT as a % of the total income, with reference to the average % of previous years</td>
<td>What is the rate of increase in IT investment expenditure as a % of total revenue in the three last year, compared with the average of previous years?</td>
<td></td>
</tr>
<tr>
<td>Alliances with partners in IT</td>
<td>Involvement Degree of the organization's various partners in determining its IT objectives and activities</td>
<td>Estimate to what extent the organization identifies opportunities for establishing alliances in IT unit with other organizations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Usefulness of the infrastructures utilized for implementing IT</td>
<td>Estimate to what extent an innovative and creative philosophy in IT is generated and supported by means of such alliances</td>
<td></td>
</tr>
<tr>
<td>Learning and growth perspective</td>
<td>Protection of IT investments</td>
<td>IT software’s right usually is considered to be a property of the IT department</td>
<td>To what extent the softwares that are made and installed in IT investment is protected through patents trade secrets, row material access.</td>
</tr>
<tr>
<td></td>
<td>Platform for growth</td>
<td>Growth in this kind of asset, should make it transparent for IT investment’s effect</td>
<td>Checking whether there is Potential in IT investment for diversification And there is an opportunity for extension</td>
</tr>
<tr>
<td></td>
<td>Durability of IT investment effects</td>
<td>Durability is the property which guarantees how long IT investment effects will remain</td>
<td>Specifying the length of IT investment’s life cycle and opportunity for incremental improvement</td>
</tr>
<tr>
<td>Learning and growth perspective (Cont…)</td>
<td>Increase in the number of the IT department personnel, compared with the increase in the number and size of IT tasks</td>
<td>How the rate of increase in numbers of IT personnel is compared with the increase in the number and size of IT tasks?</td>
<td></td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Training of the IT personnel</td>
<td>Measurement of the level of training of the IT personnel, according to the number of qualified engineers, graduates, etc., As a percentage of the total employed</td>
<td>What are the numbers of persons with degree qualifications as a percentage of the total IT personnel? Or Number with intermediate qualifications, as a percentage of the total</td>
<td></td>
</tr>
<tr>
<td>Aptitude and Attitude of the IT personnel for this type of work</td>
<td>Skills, abilities, and experience possessed by the IT personnel.</td>
<td>How do you rate the level of IT personnel’s ability, in general?</td>
<td></td>
</tr>
<tr>
<td>Adaptability of the IT personnel to the technological changes adopted and utilized in IT</td>
<td>Conflicts among the IT personnel faced with the utilization of new research technologies</td>
<td>How do you rate the capacity of the IT personnel to adapt the technological changes?</td>
<td></td>
</tr>
<tr>
<td>Labor relations climate among the IT personnel and their supervisors</td>
<td>Measurement of the human relationship’s health the among members of the IT responsible department, and their supervisors</td>
<td>How do you rate the personal relationships between the IT personnel?</td>
<td></td>
</tr>
<tr>
<td>The degree of involvement and participation of IT personnel in strategic management</td>
<td>Measurement of the personnel’s involvement in formulating the policies, strategies and plans of the company</td>
<td>How do you rate the personal relationships between the IT personnel and their managers?</td>
<td></td>
</tr>
<tr>
<td>Planning for training and Identification of competencies in IT</td>
<td>Measurement of the degree to which the capacities of IT personnel are identified, and policies of training in the capacities required</td>
<td>Indicate the degree of IT personnel’s involvement in developing the policies, strategies and plans of the company</td>
<td></td>
</tr>
<tr>
<td>Evaluation of the performance of IT personnel</td>
<td>Measurement of the degree which Performance Evaluation of IT personnel is implemented( utilization for continuous improvement of HR policies, strategies and plans related to IT)</td>
<td>To what extent does the organization provide opportunities for the IT employees so that their innovatory behavior is stimulated?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Estimate the degree of identification, classification and suitability of the knowledge and competences of the IT personnel ( with regard to the needs of the organization)</td>
<td>Indicate the degree, which the company employs innovatory organizational methods to improve the way people work. For example, restructuring the logistic chain, or working in flexible teams</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Indicate the degree, which the company employs innovatory organizational methods to improve the way people work. For example, restructuring the logistic chain, or working in flexible teams</td>
<td>How do you consider training and personal development plans are prepared and utilized?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>How do you rate the personnel involved in the current and future capacities necessary for performing IT activities?</td>
<td>What contribution do these plans make to ensure that the IT personnel are ready for the current and future capacities necessary for performing IT activities?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Estimate the degree, which the performance of the IT personnel is evaluated. How much help does the organization give them to improve their performance?</td>
<td>Indicate the degree that personnel surveys or other information sought from the employees, are utilized, to improve the HR policies, strategies and plans related to IT</td>
<td></td>
</tr>
</tbody>
</table>
To implement these indicators into DEA, according to (Rickards, 2003), in order to adopt DEA to evaluate the BSC indicators, the, all the inputs and outputs must be present and measurable for each DMU. We should also have ‘Unit’ and ‘dimension’ of every one of DMUs. DEA can handle incommensurable metrics. These unit’s metrics include monetary values, arbitrary (subjective) scales, and probability values.

In the table 3, I specified Unit for most of the indicators. I also categorized these indicators into Inputs and outputs. In the example, I used some measures as inputs which are identified by ‘*’. I considered the indicators that are highlighted as outputs.

**Table 3 BSC measures and its Units**

<table>
<thead>
<tr>
<th>Card title</th>
<th>Measures (Indicators)</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Financial perspective</strong></td>
<td>IT Investment *</td>
<td>Amount of investment in dollars (millions)</td>
</tr>
<tr>
<td></td>
<td>Discounted cash flow</td>
<td>5 years cumulative cash flow in dollars (millions)</td>
</tr>
<tr>
<td></td>
<td>Earned value</td>
<td>Dollars (millions)</td>
</tr>
<tr>
<td></td>
<td>Increase in profits of organization</td>
<td>% of increase in a year</td>
</tr>
<tr>
<td></td>
<td>Increase in the rate of financial profitability</td>
<td>% of increase in a year</td>
</tr>
</tbody>
</table>
| **Customer perspective**   | Customer focus group feedback | 1-Only minor need
|                             |                               | 4-Modest need
|                             |                               | 7-significant need
|                             |                               | 10-strong need
|                             | Customer satisfaction index   | 1-Low satisfaction
|                             |                               | 4-Average satisfaction
|                             |                               | 7-High satisfaction
|                             |                               | 10-Very high satisfaction |
|                             | Complaints                   | 1-Very high number of complaints |
|                             |                               | 4-High number of complaints   |
|                             |                               | 7-Average number of complaints|
|                             |                               | 10-Minor complaints           |
|                             | Delivery improvement         | % of improvement              |
|                             | Increase in market shares     | % of increase                 |

[41]
<table>
<thead>
<tr>
<th>Internal-business perspective</th>
<th>Congruence of IT investment</th>
<th>Importance of IT investment</th>
<th>Realistic IT budgets</th>
<th>The existence of Manuals of procedures for IT activities</th>
<th>Fluidity of information</th>
<th>Coordination between IT, production and marketing</th>
<th>Success in keeping costs to budget for the IT responsible department</th>
<th>General quality in IT activities</th>
<th>Effort of IT investment</th>
<th>Alliances with partners in IT</th>
<th>Usefulness of the infrastructures for implementing IT *</th>
<th>The cost-benefit ratio for the infrastructures utilized in IT processes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1- Only peripheral with strategy</td>
<td>1- Minimal impact, no noticeable harm if the program dropped</td>
<td>% match between IT Investment budget objectives for the department</td>
<td>1- No manual</td>
<td>1- very low communication between the IT and the other departments</td>
<td>1-very low degree of coordination</td>
<td>% of compatibility to be on budget track</td>
<td>1- low match with IT quality standards</td>
<td>% increase in annual expenditure of IT compared with the average of previous years</td>
<td>1- very low degree of alliances in IT unit with other organizations</td>
<td>1- useless</td>
<td>% of the cost-benefit ratio</td>
</tr>
<tr>
<td></td>
<td>4- Modest fit, but not with key elements of the strategy</td>
<td>4- Moderate competitive, financial impact</td>
<td>% match between IT Investment budget objectives for the department</td>
<td>3-primitive manual</td>
<td>4- low communication between the IT and the other departments</td>
<td>4- low degree of coordination</td>
<td>Success in keeping costs to budget for the IT responsible department</td>
<td>4- normal match with IT quality standards</td>
<td>% increase in annual expenditure of IT compared with the average of previous years</td>
<td>4- low degree of alliances in IT unit with other organizations</td>
<td>4- rarely useful</td>
<td>% of the cost-benefit ratio</td>
</tr>
<tr>
<td></td>
<td>7- Good fit with a key element of strategy</td>
<td>7- Significant impact, difficult to recover if investment is unsuccessful</td>
<td>% match between IT Investment budget objectives for the department</td>
<td>7- advanced manual but not complete</td>
<td>7- Normal communication between the IT and the other departments</td>
<td>7- Normal degree of coordination</td>
<td>General quality in IT activities</td>
<td>7- good match with IT quality standards</td>
<td>% increase in annual expenditure of IT compared with the average of previous years</td>
<td>7- Normal degree of alliances in IT unit with other organizations</td>
<td>7- having normal usefulness</td>
<td>% of the cost-benefit ratio</td>
</tr>
<tr>
<td></td>
<td>10- strong fit with several key elements of strategy</td>
<td>10- The success of the organization's strategy depends on this Investment</td>
<td>% match between IT Investment budget objectives for the department</td>
<td>10- advanced and full manual</td>
<td>10- perfect communication between the IT and the other departments</td>
<td>10- perfect degree of coordination</td>
<td>Effort of IT investment</td>
<td>10- complete match with IT quality standards</td>
<td>% increase in annual expenditure of IT compared with the average of previous years</td>
<td>10- perfect degree of alliances in IT unit with other organizations</td>
<td>10- very useful</td>
<td>% of the cost-benefit ratio</td>
</tr>
</tbody>
</table>
| Protection of IT investments | 1-IT softwares easily copied  
4-IT softwares Protected but not a deterrent  
7-IT softwares protected by trade secrets, patents and …  
10-IT softwares Solidly protected through a combination of patents trade secrets, row material access, etc. |
| Platform for growth | 1-Dead and/one of kind  
4-Other opportunities for extension  
7-Potential for diversification  
10-Opens up new technical and commercial fields |
| Durability of IT investment effects | 1- No distinctive advantage  
4- short term life cycle  
7- moderate life cycle but little opportunity for incremental improvement  
10- long life cycle with opportunity for incremental improvement |
| Increase in the IT personnel | Increase in the number of persons in the IT department |
| Learning and growth perspective |  |
| Training of the IT personnel* | % of Number of persons with degree level qualifications to total IT personnel  
1-basic skills personnel  
4- normal skills personnel  
7- good skills personnel  
10- highly good skills personnel |
| Rate the level of ability and experience of the IT personnel* | 1- very low degree of adaptability  
4- low degree of adaptability  
7- Normal degree of adaptability  
10- perfect degree of adaptability |
| Adaptable the technological changes | 1-not having a good relation  
3-having a normal relation  
7-having a good relation  
10- having a very good relation |
| Labor relations climate | 1- Low degree of involvement  
4- normal degree of involvement  
7- good of involvement  
10- high degree of involvement |
| Degree of involvement IT departments in strategic management |  |
| Planning for training and Identification of competencies in IT | Number of hours training from the organization per employee  
1- performance evaluation of IT personnel is not useful other plans  
4- performance evaluation of IT personnel is somehow useful other plans  
7- performance evaluation of IT personnel is useful other plans  
10- performance evaluation of IT personnel is very useful other plans |
8.4 Using DEA for integrated model

In the second step of proposed approach, DEA method is used for ranking alternatives (DMUs).

First task in developing a DEA-based model is to select an appropriate formulation (e.g. CCR, BCC and…) that best fits the organization’s environment. For example, when evaluating a set of diverse IT investments proposals with significantly different resources requirements, which are competing for the same resources, a variable return-to-scale model like the BCC model is more appropriate. Nevertheless, when the IT investments proposals are homogeneous, a constant return-to-scale model like CCR may be more suitable. Eilat and Golani (Eilat et al., 2008) used the same reasoning in their work for ranking R&D projects with BSC-DEA method.

In BSC- BSC model, Each DMU can be as follows:

1. Different IT investments proposals
2. Different ongoing IT investment projects
3. Different IT investments Effect on one organization (on different years)
4. Comparing different organization’s efficiencies in effect of IT investments

The presented model is using the original CCR model by integrating into it a BSC structure. In the example given, we try to compare homogeneous IT investments proposals for one organization, so based on (Eilat et al., 2008) it is better to use a constant return to scale model (like CCR). I have used the output oriented CCR because the inputs are available based on the proposals and the organization try to use them all and to maximize its outputs. All the input and output values in DEA represent measures in BSC and vice versa.

9 Example

9.1 Purpose

To show how the proposed model works and how the DEA compares DMUs, I used an example. This example shows how we put measures from BSC to DEA. All the numbers are made by the author to show the functionality of the integrated model of BSC-DEA.

9.2 Selecting Appropriate Indicators

Different organizations usually have a different approach for the selection or control of their IT investment. One common approach is giving the managers the flexibility of deciding their desired preferences among perspectives of the IT success. (Eilat et al., 2008)
Based on this view, selection of different inputs and outputs of the proposed model is arbitrary. It is based on managerial view of IT investment's situation. Managers can give more attention to what is more attractive to the organization by selecting these preferences, and then use BSC-DEA accordingly. I have chosen quite arbitrary inputs and outputs for this example just to show how this integrated model works.

9.3 Example results

In the discussion that follows, I assume that there are ‘n’ IT investments proposals. IT investments proposal ‘r’ consumes amounts ‘k’ of inputs and produces ‘m’ outputs.


I have considered arbitrary data for each unit of inputs and outputs. Now DEA model can show how it works and how it gives us the efficiency results. I have used DEA-Solver LV3(DEA-Solver Pro5.0) software from (Cooper et al., 2007).

Table 4 shows the inputs and output indicators and the numerical amount that I have considered for each of indicators.
| DMU 1 | 120 | 4 | 10 | 75% | 80 | 20% | 1 | 3% | 4 | 4 | 4 | 1 | 1 | 1 |
| DMU 2 | 75  | 1 | 4  | 45% | 136| 45% | 7 | 5% | 7 | 4 | 10| 7 | 7 | 4 |
| DMU 3 | 150 | 7 | 4  | 80% | 120| 21% | 7 | 7% | 7 | 1 | 4 | 1 | 1 | 4 |
| DMU 4 | 210 | 4 | 1  | 50% | 310| 22% | 7 | 8% | 4 | 4 | 7 | 7 | 4 | 4 |
| DMU 5 | 350 | 10| 7  | 90% | 150| 28% | 4 | 2% | 7 | 7 | 1 | 7 | 10| 4 |
| DMU 6 | 270 | 7 | 10 | 90% | 250| 21% | 7 | 5% | 4 | 4 | 7 | 4 | 7 | 1 |

Table 4 Inputs and output indicators
10 Analysis and Results

10.1 Result summary

The presented model is using the original CCR by integrating into it a BSC structure. Because in the example given, I try to compare homogeneous IT investments proposals for one organization, so based on (Eilat et al., 2008) it is better to use a constant return to scale model (like CCR). I used output oriented CCR. As DEA-Solver Pro5.0/ CCR (CCR-O) solve the DEA model, the results are as shown in table 5;

<table>
<thead>
<tr>
<th>Rank</th>
<th>DMU</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DMU4 (proposal N.4)</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>DMU 2 (proposal N.2)</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>DMU 3 (proposal N.3)</td>
<td>0.915385</td>
</tr>
<tr>
<td>4</td>
<td>DMU 5 (proposal N.5)</td>
<td>0.889344</td>
</tr>
<tr>
<td>5</td>
<td>DMU 6 (proposal N.6)</td>
<td>0.632431</td>
</tr>
<tr>
<td>6</td>
<td>DMU 1 (proposal N.1)</td>
<td>0.625</td>
</tr>
</tbody>
</table>

Table 5 DEA results

As we see in table 5, DMU 4 (IT investment proposal N.4) and DMU 2 (IT Investment proposal N.2) are efficient, both with score of 1. DEA has rank both of them as first. Rest of the DMUs (IT proposals) has different scores below 1. Figure 11 shows a graphical view of each DMUs score.

Figure 11 DEA results
10.2 Results Analysis

As we see in table 5, DMU 4 and DMU 2 are efficient, both with a score of 1. DEA has ranked both of them as first. We should recall that in the CCR model, the efficient DMUs should have the highest output-to-input ratio in any output-input pair. The rest of DMUs has different scores below 1. Figure 11 shows a graphical view of the scores that each DMU has gained.

IT investment proposal No. 2 (DMU 2) received a score of 1 since it has 6 maximal ratios: the highest increase in profits, the highest Customer satisfaction index, the highest Congruence of IT investment, the highest Fluidity of info, the highest degree of involvement and the highest Platform for growth score to investment ratio. If we look closely, we find out that it has also the lowest input in three amounts out of 4 inputs so it is very probable that DMU 2 is efficient. DMU 2 is the benchmark and reference for another four DMUs to measure their efficiency.

IT investment proposal No. 4 (DMU 4) also received a score of 1 since in CCR model, many DMUs can be marked as efficient. DMU 4 has five maximal ratios: the highest Earned value, the highest Customer satisfaction index, the highest increase in market shares, the highest degree of involvement, and the highest Platform for growth and it has two lowest amounts out of four inputs. Therefore, it is reasonable that CCR recognizes it as the efficient DMU.

Table 6 shows that DMU 2 has been the reference for four DMUs and DMU 2 is the reference for three DMUs. We see that some inefficient DMU like DMU3 can have a benchmark regarding DMU2 or DMU4. Each reference set gives different efficiency scores for the inefficient DMUs.

<table>
<thead>
<tr>
<th>Reference set</th>
<th>DMU 1</th>
<th>DMU 2</th>
<th>DMU 2</th>
<th>DMU 2</th>
<th>DMU 4</th>
<th>DMU 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMU 1</td>
<td>DMU 2</td>
<td>1.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMU 2</td>
<td>DMU 2</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMU 3</td>
<td>DMU 2</td>
<td>0.901661</td>
<td>DMU 4</td>
<td>0.392157</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMU 4</td>
<td>DMU 4</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMU 5</td>
<td>DMU 2</td>
<td>1.677419</td>
<td>DMU 4</td>
<td>0.290323</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMU 6</td>
<td>DMU 2</td>
<td>1.137763</td>
<td>DMU 4</td>
<td>0.776013</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6 reference DMUs
10.3 Managerial conclusions

The above results have some managerial conclusions,

- With these results, managers receive a clear indication of every IT investment’s proposal success. IT proposals with high relative ratings would get more attention and resources of organization, whereas inefficient IT proposals might be eliminated.

- Using DEA as the analytical tool among IT investment proposals, DEA’s scores imply that there are various points to improve, compared to efficient DMUs. But according to (Rickards, 2003), we must consider that in a practical work, the potential input savings or output increases are not always attainable. For example, we cannot eliminate a DMU’s inefficiencies when they have small amounts of an indivisible input or output unit.

- We should also consider that the source of the savings or increased production potential is not always evident from the analysis so we need more study on identification of inefficiency sources. If the DMUS were those organizations that have implemented IT investment projects, the result provides the benchmark for each organization.

This managerial conclusion, together with following conclusion part, is direct answer to the fourth research question.

11 Discussion

11.1 Conclusions

First, this thesis has shown that the Balanced Scorecard can be used as a performance management tool for evaluating an organization’s efficiency. The four dimensions of the Balanced Scorecard link organization’s strategies with indicators, and help management establish an integrated efficiency assessment system for evaluation of IT investments proposals.

Second, this thesis has shown that the DEA model can be used to generate one single efficiency figure in multi-input and multi-output situations. DEA performs optimization analysis on each individual unit (DMUs) and generates relative efficiency value of each DMU. Through DEA, management will know the overall efficiency indicator and will know the origins of inefficiencies. The DEA model has many benefits. For example, it can accommodate diversified variables of different measuring units.

I have also stated some shortcoming of BSC for my intended goal. I have studied some advantages that DEA can have for evaluating IT impacts on the organization's performance. DEA can fill the shortcoming of BSC. With introducing BSC-DEA model
and using the example, I have shown the reasoning and the theory behind this model. I have also identified the benefits of this model for evaluation of IT investment’s effect.

The proposed DEA–BSC model advances the individual capabilities of both DEA and BSC.

**From the viewpoint of DEA**, the integrated model generalizes the standard treatment of the data by dividing the inputs and outputs into subsets (perspectives of BSC). The integrated model has considered a holistic view of an organization like financial and non-financial, short-term and long term. It is helpful for the data that DEA uses.

**From the viewpoint of BSC**, the integrated model proposes a new approach to evaluate performance by applying quantitative analysis that combines the measures within each card into a single value. Integrated model also addresses some of the difficulties in existing BSC applications. For example, BSC does not produce a single, comprehensive measure of performance that is because it does not have a mathematical model or a weighting scheme to make comparisons. In addition, the complexity of BSC and the interrelated nature of the BSC indicators is another difficulty that I have solved it by introducing the BSC-DEA integrated model.

### 11.2 Implications for subject area

Two groups would gain benefits from this thesis:

1. The research society, who focus on a new way to evaluate the impact of IT on any organization,

The research field will gain a better understanding of evaluating IT effects on an organization with the strategic view. Throughout the chapters in this thesis, I developed a new method that might be beneficial to related researchers. Higher awareness about the importance of strategic view on the IT investment is beneficial because it emphasis on why IT investment affects an organization. Secondly, better knowledge and understanding of BSC-DEA can provide guidelines for future research areas not currently understood.

2. The practitioners and managers, who face difficulties when managing and evaluating the company’s IT investment projects,

Another group that benefit from the thesis is practitioners and managers. This thesis is very relevant to consulting companies that focus on IT consultancy, as this thesis gives them a better knowledge of how to select an IT evaluation method and how to evaluate their IT proposal regarding the organization's strategic goals.
By applying BSC-DEA model in practice, top management gives IT investment managers the privilege to decide how their IT investment should be evaluated. For example, management can decide how much the financial perspective is more important than the internal-business or costumer perspectives.

Based on the descriptions above, it is possible to have both research and commercial use. This thesis is a small step forward that can benefit both research and practice. However, researchers should cover many topics in this area.

11.3 Method evaluation

To have the understanding of the problem area, I used different concepts from strategic management, efficiency measurement, and IT evaluation. It was sometimes difficult to combine these concepts together because they have different assumption. There is also an overlap between these subjects. Therefore, I had to adapt some of concepts in the subjected area before using them.

Another issue was the fact that there are not so many papers about IT investment’s effect on the organization's efficiency. Therefore, I had to adopt closest methods from strategic management, efficiency measurement, and IT evaluation into my desired direction. For example in comparing the efficiency of an organization in different years in regard to IT effects.

These efforts have made it possible to relate my research questions to previous researches and my presented method.

11.4 Result evaluation

I have used strong literature study to clarify my research questions. The text analysis has identified some general qualities of BSC and Strategic value of IT. I identified important factors for the creation of BSC template. I joined different concepts into a whole about IT investment. It will clarify the research questions. I combined the main sources of this thesis in contribution in making this thesis idea.

In conclusion part, I have clearly shown how my conclusions are driven by earlier parts of this thesis. The presented model (BSC-DEA) is credible from both perspectives as I addressed in conclusion part. Showing the benefit both from BSC and DEA perspectives validates the results of this study.

11.5 Possibilities to generalize

My research uses BSC-DEA model for IT evaluation. As I have shown in literature studies, we can use BSC in any other organization. There are many papers on this issue.
Thus, importing BSC into DEA is possible concerning which item or criteria we want to emphasize in this integrated method. This means that we can use this model for any organization that we want to evaluate its efficiency.

Based on the content and reasoning of BSC-DEA model, we can also have this model as a dependent variable to study how and why some organizations are more efficient than others, both for-profit and non-profit organizations.

11.6 Ideas for continued research

It would be interesting to see a more comprehensive study in this field. By continuing this thesis evolutionary approach, future researchers can make more precise model for specific organizations. A fuzzy DEA-BSC model or network DEA-BSC model can be a good approach for this purpose.

A more comprehensive empirical study may also produce a numerical material. It would be useful to interpret and discuss an empirical study in area of quantitative analysis. Such a study could also include observations to enhance the experience of IT investments in organizations.
12 References:


[53]


Högskolan i Borås är en modern högskola mitt i city. Vi bedriver utbildningar inom ekonomi och informatik, biblioteks- och informationsvetenskap, mode och textil, beteendevetenskap och lärarutbildning, teknik samt vårdvetenskap.


Våra ekonomiutbildningar ger studenterna möjlighet att lära sig mer om olika företag och förvaltningar och hur styrning och organisation av dessa verksamheter sker. De får även lära sig om samhällsutveckling och om organisationers anpassning till omvärlden. De får möjlighet att förbättra sin förmåga att analysera, utveckla och styra verksamheter, oavsett om de vill ägna sig åt revision, administration eller marknadsföring. Bland våra IT-utbildningar finns alltid något för dem som vill designa framtidens IT-baserade kommunikationslösningar, som vill analysera behov av och krav på organisationers information för att designa deras innehållsstucturer, bedriva integrerad IT- och affärsutveckling, utveckla sin förmåga att analysera och designa verksamheter eller inriktta sig mot programmering och utveckling för god IT-användning i företag och organisationer.

Forskningsverksamheten vid institutionen är såväl professions- som design- och utvecklingsinriktad. Den övergripande forskningsprofilen för institutionen är handels- och tjänsteutveckling i vilken kunskaper och kompetenser inom såväl informatik som företagsekonomi utgör viktiga grundstenar. Forskningen är välrenommerad och fokuserar på inriktningarna affärsdesign och Co-design. Forskningen är också professionsorienterad, vilket bland annat tar sig uttryck i att forskningen i många fall bedrivs på aktionsforskningsbaserade grunder med företag och offentliga organisationer på lokal, nationell och internationell arena. Forskningens design och professionsinriktning manifesteras också i InnovationLab, som är institutionens och Högskolans enhet för forskningsstödjande systemutveckling.