Investigation of The Decision Making Process for Technology Investment in The Saudi Arabia Petrochemical Industry

Submitted in Partial Fulfillment of the Requirements of the Degree of Doctor of Philosophy, January 2012

School of Mechanical, Aerospace and Civil Engineering, The University of Manchester,

Tariq Alsahtli
# Table of contents

Abstract ........................................................................................................................................ 6

ACKNOWLEDGEMENT ............................................................................................................... 7

DECLARATION .......................................................................................................................... 8

Chapter one Introduction
1.1 Introduction .................................................................................................................. 9
1.2 The purpose and importance of the research ............................................................. 9
1.3 The research problem ................................................................................................ 10
1.4 The research aim and objectives .............................................................................. 11
1.5 The research methodology of the study ................................................................... 12
1.6 The structure of the thesis ....................................................................................... 13

Chapter The Saudi petrochemical industry and technologies
2.1 Introduction ................................................................................................................ 17
2.2 Background of the Saudi economy and the oil industry ......................................... 17
2.3 The structure and current state of the petrochemical sector in Saudi Arabia ........ 18
2.4 Issues and factors affecting the Saudi petrochemical industry ............................... 21
2.5 Petrochemical feedstock and technologies ............................................................ 23
2.6 Summary ................................................................................................................... 25

Chapter Three: Factors influencing the investment decision
3.1 Introduction ................................................................................................................ 27
3.2 The complexity of technology investment decisions ............................................. 27
3.3 Factors related to decision-making over technology investment ......................... 28
3.3.1 Environmental (internal and external) factors ..................................................... 29
3.3.2 Organizational Factors .................................................................................... 30
3.3.3 Operational factors ........................................................................................ 31
3.3.4 Top management related factors .................................................................... 31
3.4 Company readiness and the technology investment decision ............................. 33
3.4.1 Investment readiness ..................................................................................... 33
3.4.2 Operational system readiness ....................................................................... 34
3.4.3 Technology Readiness Level (TRL) ............................................................... 34
3.4.4 Manufacturing readiness ............................................................................. 36
3.5 Technology alignment with the business .............................................................. 37
3.6 Summary ................................................................................................................... 39

Chapter Four: The impact of investment justification and benefit realization on the technology investment decision
4.1 Introduction ................................................................................................................ 41
4.2 Investment justification and technology investment decisions ........................... 42
4.3 Difficulties with justifying new technology investment .......................................... 43
4.3.1 The economic or financial approach ............................................................... 45
4.3.2 The strategic approach ................................................................................ 46
4.3.3 The analytic approach ................................................................................ 47
4.3.4 Comparison of approaches ......................................................................... 47
4.4 Top management involvement and justifying the investment ............................... 51
4.5 Importance of technology selection .................................................................... 52
7.5.3 The impact on the decision progress .................................................................166
7.6 Investment readiness and abilities .................................................................170
7.6.1 The process of measuring investment readiness and company abilities ..........170
7.6.2 Factors and difficulties affecting the ability to invest ....................................174
7.6.3 The impact on the decision progress .............................................................176
7.6.4 Alignment actions .........................................................................................179
7.7 Summary .............................................................................................................183

Chapter Eight: Discussion and recommendations
8.1 Introduction .........................................................................................................186
8.2 Summary of the research conducted .................................................................186
8.3 The key research findings and discussion .........................................................187
8.4 Summary .............................................................................................................200

Chapter Nine: Conclusion and Future Work
9.1 Introduction .........................................................................................................203
9.2 Research contributions ......................................................................................203
9.3 Limitations of the study and implications for further research .......................205

References ...............................................................................................................207
Appendix 1: First study questionnaire .....................................................................228
Appendix 2: second study questionnaire ..................................................................231
Appendix 3: Terms and definition ...........................................................................237

List of figures
Figure 1.1: Thesis Structure .....................................................................................15
Figure 2.1 Forecast of Saudi Arabia’s oil production up to 2015 ............................18
Figure 2.2 Saudi Arabia’s share of global petrochemicals production ..................20
Figure 5.1: The implemented structure and process for this study .........................66
Figure 5.2: Components of data analysis: Model ......................................................74
Figure 6.1: Company A investment decision making process ...............................89
Figure 6.2: Company B investment decision making process ...............................91
Figure 6.3: Company C investment decision making process ...............................94
Figure 6.4: Company D investment decision making process ...............................96
Figure 8.1: Framework for technology investment decision-making .....................198

List of tables
Table 3.1: Factors related to technology investment summarized from the literature review ......29
Table 3.2: Technology Readiness Levels in the Department of Defense (DoD) ............35
Table 3.3: MRL dimensions and threads. .................................................................37
Table 4.1: Various methods used to make the investment decision .....................44
Table 4.2: Justification methods for advanced manufacturing technologies ..........48
Table 5.1: A Summary of Differences between Quantitative and Qualitative Research ......64
Table 5.2: Advantages and Disadvantages of Quantitative and Qualitative Research Methods...64
Table 5.3: The interviewed respondent’s in the four companies for both studies .......71
Table 5.4: The examined research aspects and issues for the first study linked with research objectives

Table 5.5: The examined research aspects and issues for the second study linked with research objectives

Table 5.6: Example of a simple matrix of how the respondent's answers were recorded and summarized for each respondent in the first and second research study

Table 5.7: Example for the categorization of the analyzed data for investment benefits

Table 6.1: Stages one and two of company B’s decision making process

Table 6.2: Investment justifications findings from study one

Table 6.3: Technology selection findings from study one

Table 6.4: Readiness findings from study one

Table 6.5: Technology alignment findings from study one

Table 6.6: Benefit realization findings from study one

Table 7.1: The Interviewees' in the first and second study

Table 7.2: The found criteria's, factors of investment benefit realization and its impact on decision making process

Table 7.3: The found criteria's, factors of investment justifications and its impact on decision making process

Table 7.4: The found criteria's, factors of technology selections and its impact on decision making process

Table 8.1: Summary of factors affecting the investment decision making process

Table 8.2: Important factors related to technology selection were identified from the literature and the conducted interviews.
Abstract

Companies and organizations in different industries around the world make use of different technologies for many reasons and purposes, such as to improve performance and to stay competitive. This raises some questions and concerns about the use, benefit, risk and the investment decision-making process for the selected technology. A review of the available literature shows that the decision-making processes related to investments in general are difficult and complex. As a result of this, many organizations that have invested in technology have not achieved the required benefits; this leads to unsuccessful investment decisions and loss of opportunities. This can occur when decision makers and planners do not pay enough attention to some critical factor that may affect the investment, or they may just not have planned sufficiently carefully for it.

This research aims to examine and investigate the gaps and factors behind technology investment decisions, with a focus on several of the more important factors and elements that may have a huge impact on these decisions. These include investment justification techniques, technology selection, organizational readiness, technology alignment, and benefits realization. The unique aspect of this research is that these five elements have not previously been linked in research publications or reports, particularly within the petrochemical industry. Thus, the research focuses on these five elements to identify the critical factors and difficulties to support decision makers in order to achieve successful technology investment in the petrochemical industry. To address the research aims, the issues affecting investment decision-making within a number of the biggest petrochemical companies in Saudi Arabia were investigated.
ACKNOWLEDGEMENT

In the name of God

I would like to thank all the people who helped and supported me to conduct this research study. In would like to deeply thank my most gratitude to Dr Therese Lawlor-Wright for her valuable advice and expert guidance all through during this work.

I would like also to thank my colleagues for their invaluable friendship, the administrative staff and all whom who have contributed directly or indirectly to the compilation of this research study.

Finally, I am grateful to my family for their continuous support and encouragement.
DECLARATION

I declare that the research contained in this thesis was conducted by me. It has not been previously submitted or used to this or any other Institution for the award of a degree of any other qualification.

TARIQ ALSAHLI
Chapter One
Introduction

1.1 Introduction

This research investigates the factors and difficulties that affect petrochemical companies’ technology investment decisions and the relationships and impact these factors have on the investment decision. The aim of this chapter is to provide an overview of the research problem and identify the aims and objectives of this research. In addition, this chapter will describe the applied method for this study. Finally, the chapter will also describe the structure of this thesis and the definitions and acronyms used for this research study.

1.2 The purpose and importance of the research

In the 21st century, the majority of organizations and companies cannot operate without technology playing a major part in their processes. Over the past few decades, various technologies have played a key role in enhancing the performance and method of doing business in organizations within many industries (Ariss et al., 2000). Technology has also had a positive impact on the competitiveness, innovation and financial performance of firms. It has changed the behaviour of business operations, management and the production process in manufacturing companies (Noori, 1997; Shepherd et al., 2000).

In spite of technology’s ability to bring benefits, several researchers and reporters have identified many organizations that realized their technology investment was not bringing or delivering advantages, which had led to wasted investments and missed opportunities,
and was therefore considered to be an unsuccessful investment (Francke, 2003; Somers and Nelson, 2003; Tan et al., 2006). A review of current literature shows that several factors are involved in technology failure, including technological, individual, operational, managerial and external factors. The effectiveness of the decision-making process is considered a critical factor in ensuring the success of the technology investment.

There is strong evidence that unsuccessful technology investment can be caused by the decision-making process method, as well as the top management’s or decision makers’ roles and responsibilities in making the investment decisions (Anderson et al., 2001; Juliusson et al., 2005; McGaughey and Roach, 1997). This requires serious attention from researchers, consultants and decision makers themselves. This research investigates these issues to produce recommendations to support decision makers in improving the decision-making process with regard to technology investments.

1.3 The research problem

Feibel (2003) defines investment as “an initial forfeit of something we value in exchange for the anticipated benefit of getting back more than we put in”. Butler (1993) defines investment decisions as “the decision to commit a firm’s resources (capital, people, know-how, and so on) to particular projects with the intention of achieving greater and other benefits in future years”. Companies and organizations invest in or develop new technologies to support their operations and processes in order to gain better organizational performance and to meet their business objectives. However, making strategic decisions to invest in new advanced manufacturing technology is difficult and complex (Sambasivarao and Deshmukh, 1997; Tan et al., 2006a, 2006b). Various external and internal factors which may affect the investment and potential benefits of the technology may be difficult to estimate.
With regard to the petrochemical industry, investing in and implementing new manufacturing technologies are two of the main contributory factors to achieving competitiveness. Gaining full benefits from technologies requires decision makers to be aware of all the possible factors and difficulties that may affect technology investment in petrochemical projects. Making technology investment decisions for petrochemical projects is difficult because of the internal, external, and environmental economic issues and factors that may affect a company’s plans to meet its business objectives. This research aims to investigate the managerial and planning issues affecting technology investment in the Saudi petrochemical industry.

1.4 Research aims and objectives

Investigating the technology investment decision and its related factors and difficulties is important in order to achieve successful investment. Understanding the factors and difficulties will help petrochemical companies to realize the expected benefits from the investment. This research aims to identify the factors and difficulties that lie behind the complexity of the technology investment decision-making process by looking at the technology investment decisions in the Saudi petrochemical industry.

In order to achieve the aims, the following objectives must be fulfilled:

1. Identify the internal and external factors and difficulties that influence technology investment decision-making and evaluation practices in Saudi petrochemical companies.

2. Understand how petrochemical companies measure the level of readiness to invest in new technology and what factors/difficulties affect the Saudi companies’ ability to invest.
3. Examine the investment justification approach that companies are using and investigate the factors that may affect justifying the technology investment in the decision making in petrochemical companies in Saudi Arabia.

4. Investigate the technology selection methods and criteria that Saudi petrochemical companies use and how/what factors can impact the investment decision.

5. Examine the applied alignment actions within Saudi petrochemical companies and how they can impact the investment decision.

6. Identify the factors and difficulties which impact identifying benefits for technology investment.

7. Propose a framework for technology investment decision making to support decision makers in achieving successful investment in the Saudi petrochemical industry.

1.5 The research methodology of the study

To address the research aims and objectives, a review of the relevant literature was conducted to explore all aspects of the investment decision-making process. This was followed by two different studies to investigate current practice within petrochemical companies in Saudi Arabia. To achieve this, a qualitative research method was used. Chapter five discusses the research methods and techniques used.

The research began with an exploratory study aimed at identifying Saudi petrochemical business executives’ approaches to the investment decision-making process, and the difficulties and issues that these companies faced during their planning for investments. Data was collected from four Saudi petrochemical companies using a semi-structured
interview approach. This was followed by a second study, which utilized a qualitative research methodology. Case study research methodology was selected to enable an in-depth investigation of the decision-making process within four companies in order to gain an insight into the research problem and the key elements of the technology investment decision-making process. These provided empirical evidence about the applied decision-making process and the factors and difficulties that Saudi petrochemical companies are facing. Analysis of the four case studies was conducted by individual case study analyses. This was also followed by a cross-case analysis, which was performed in order to address the research questions and objectives.

Chapter five discusses the method used to select the four Saudi petrochemical companies. The limited overall number of petrochemical companies in the country (around 11) gave rise to some difficulties in meeting contacts and arranging interviews. The four companies were selected to represent different sizes, levels of investment, projects and locations within the industry.

1.6 The structure of the thesis

This thesis is divided into eight chapters (see Figure 1.1). These chapters include the following:

Chapter one: Presents the purpose and importance of the research followed by identifying the research problems, aims and objectives, research questions and the research design and structure.

Chapter two: Reviews the current state of the petrochemical industry in Saudi Arabia and its importance in growing the economy. Also, this chapter provides an overview of petrochemical technologies.
Chapter three: Discusses internal and external factors that may affect investment decisions. It also discusses the importance of investment readiness and its impact on the investment. This is followed by a review of operational and manufacturing readiness.

Chapter four: Identifies the importance and impact of investment justification and benefit realization in making technology investment decisions. Also it reviews several approaches and techniques in investment justification and benefit realization.

Chapter five: Identifies the most appropriate research methodology strategy to conduct this research. This chapter also discusses the adopted approaches, data collection methods and data analysis. The chapter describes the two research studies, which are detailed in subsequent chapters.

Chapter six: Provides an analysis of the first research study. The results of each case are presented to address the research aims, objectives and questions. The chapter presents the analysis for the first study of four petrochemical companies’ investment decision-making processes and the factors and difficulties faced. Factors and difficulties related to their investment readiness, investment justification, selection of technologies, realising the investment benefit, and alignment actions will be analysed and discussed in this chapter.

Chapter seven: Provides an analysis and discussion for the second research study of the four case studies in order to achieve the research objectives and to address the research questions. Each element of the research investigations and findings from each case are compared and summarized.

Chapter eight: Provides a summary and conclusions to the whole research study. Implications of the study will also be discussed and suggestions for future research will be presented.
Figure 1.1: Thesis structure
Chapter two
The Saudi petrochemical industry and technologies
Chapter two
The Saudi petrochemical industry and technologies

2.1 Introduction

This chapter provides a review of the Saudi Arabian petrochemical industry, starting with the Saudi economy and the impact of oil production, past developments and future trends. The chapter also looks at the structure of the petrochemical industry in Saudi Arabia and the factors and issues faced by the industry. The chapter also reviews the technologies used by the industry.

2.2 Background of the Saudi economy and the oil industry

At present, Saudi Arabia’s economy is constituted largely of oil and its concomitant industries, such as the refining of petrol and related petrochemical production. Oil production accounts for approximately 30% of the nation’s GDP, accumulating 80% of national revenue (OPEC Annual Statistical Bulletin, 2008). It is reported that 90% of export revenue is related to oil, and Saudi Aramco expects to increase its output to over 12 million barrels per day in 2012 (OPEC Annual Statistical Bulletin, 2008). Therefore, the state of the Saudi economy and its future outlook are based heavily on oil prices and world demand for oil. In addition, Saudi Arabia is also fourth in the list of gas-producing countries (Saudi Ministry of Petroleum and Mineral Resources, 2009). Because of its oil and gas industry, Saudi Arabia’s economy is the largest in the Middle East region.
In spite of restrictions imposed by OPEC in recent times, capacity is being extended by Saudi Aramco, as mentioned above. The drilling of certain fields has been expanded to make better use of older works. This also allows Saudi Arabia to provide oil and gas at the lowest possible prices, something which the country prides itself on (Aramco, 2007). Consequently, the estimated oil and gas output is expected to increase within the decade to approx 12.5 million barrels per day by 2015 (see Figure 2.1).

Figure 2.1 Forecast of Saudi Arabia’s oil production to 2015 (Source: EIA, 2008)

2.3 The structure and current state of the petrochemical sector in Saudi Arabia

Because oil and gas production is the main industry in Saudi Arabia, and to support the country’s economic and political position, the Saudi government strategy is to assist other industries associated with oil and gas such as the petrochemical industry. This is done by
helping the private sector and investors to participate in the development of the economy, particularly in the petrochemical industry and its related industries (Saudi Arabia Ministry of Culture and Information, 2009).

In the past four decades, a number of companies have been established to form the basis of the petrochemical industry in Saudi Arabia. Saudi Basic Industries Corporation (SABIC) was founded in 1976 to help build the industry by promoting technology and knowledge transfer and thus help ensure that Saudi Arabia is independent of the global petrochemical companies (SABIC, 2007).

As a result of the government strategy to develop the country’s petrochemical industry, Saudi Arabia dominates the region’s petrochemical sector, accounting for 70% of the Gulf Cooperation Council’s (GCC) petrochemical production, which is about 7% of global production and is expected to increase to 10% by 2014 (Samba, 2009; Zawya, 2009; Zawya, 2010). However, the Saudi government’s strategy since the early 2000s has also aimed to develop the petrochemical industry by establishing more petrochemical companies such as Sipchem, Saudi Kayan, Yansab, NAMA, Tasnee, and Petro Rabigh. As a result of this expansion, Saudi Arabia is now the second largest producer of ethylene glycol and methanol in the world. In addition, it is also thought to be the third largest producer of polyethylene, and the sixth largest producer of polypropylene (Al-Mady, 2004; Zawya, 2010; see Figure 2.2).
In terms of tonnage, Saudi Arabia produced 40 million tonnes of petrochemical products per year in 2005. This was expected to have risen to approximately 75 million tonnes per year in 2010, which would amount to 13% of worldwide production. This includes energy-based products such as steel and fertilizers (5 million tonnes each) and ethylene and propylene by-products (20 million tonnes each). This vast production makes the petrochemical industry the second most important in the Saudi economy, immediately following oil production itself (Al-Mady, 2004). The growth of the petrochemicals sector has been associated with a vast amount of resources input and very high costs. Investments of approximately $50 billion are contained in the two main industrial cities in Saudi: Al-Jubail and Yanbu. In addition, around 600 other locations manufacture by-products from petrochemical resources (SABIC, 2010). It is expected that in future the capacity for production will double, and Saudi Arabia is likely to become the fourth largest worldwide producer of petrochemicals (TAIB Bank, 2007).
2.4 Issues and factors affecting the Saudi petrochemical industry

Petrochemical industries all over the world faced many issues and factors affecting their performance, production and investment. In 2007, Al-Mady (Vice Chairman and Chief Executive Officer of Saudi Basic Industries Corporation SABIC) identified several factors affecting the petrochemical industry in the Middle East and Saudi Arabia specifically. These issues and factors are summarized as follows:

- The availability of resources is one of the most important issues facing the petrochemical industry in Saudi Arabia. It is of great significance to the Middle East regions that its land yields great quantities of petroleum feedstock at minimal cost when compared to other regions, which allows the production of petrochemical derivatives at a good price. It is important for Saudi Arabia to maintain its costs at such favorable rates.

- Petrochemical industries must ensure that the technology they employ makes the best possible use of the resources available. They must also constantly investigate further technologies and further uses for those already being applied (Al-Mady, 2007). If they fail to do this, any petrochemical industry will fall behind the market and lose whatever advantage it might gain.

- Another issue to be considered is the need for qualified labour that is capable of handling the complex features of the petrochemical industry. There is anxiety in Saudi Arabia concerning the skills required to maintain a fine quality of service in engineering, manufacture, and also the marketing of products. However, basic training is not necessarily enough to give the company a competitive edge over other producers that may have even better qualified employees (Al-Mady, 2007).

- Another issue for the petrochemical industry is the possible risks of the financial markets, which are becoming more prevalent. This gives rise to the need to vary the sources of finance, preferably avoiding the need for loans if at all possible.
Environmental changes are seen as a result of the global excess of CO$_2$, the emission of manmade hydrocarbons, in which the petrochemical industry must face the fact that it contributes on a large scale to this emission. It will become vital for this industry to address the problem, adjusting the construction of new or old factories to decrease the amount of CO$_2$ produced (Al-Mady, 2007).

With regard to the success factors, the petrochemical industry is aware of four features that will prove vital in ensuring its long-term success (Glass, 2007):

1. Flexible differences in cost, quality, and availability of feedstock;
2. Efficient use of energy to reduce CO$_2$ emissions;
3. Attention paid to cost, efficiency, safety, and reliability;
4. The use of latest technology to be competitive, as suits customers’ needs.

If a company is aiming to meet the demands of the market it must employ the latest technology to improve its manufacturing capability, creating the finest possible products efficiently and at a good price. The products manufactured can find both new markets and innovative uses. The markets highlight a need for improved transportation, new construction, and an increasing concern worldwide about the importance of health care. If the products can be seen to help advance the quality of life, the demand for them will doubtless increase. The technology in use must be capable of processing different types of feedstock, and achieving greater development. The management of resources and technology, along with cooperation between government and manufacturing industries, is crucial if the nation is to challenge the demands of the oil and chemical industries.

Saudi Arabia plans to invest $100 billion in its petrochemical industry by 2015. It wishes to focus more on advanced technology (Al-Suwaiyel, 2011). The kingdom aims to develop these technologies in partnership with the private sector. It is expected that production within the petrochemical industry will increase to 80 million tonnes per year. Its current production is 60 million tonnes, representing 62% of total GCC petrochemical
capacity. For the higher output to be achieved, the advancement of new technology for the industry must progress. The next section reviews different technologies used in the petrochemical industry.

2.5 Petrochemical feedstock and technologies

For manufacturing industries, technology is a crucial part of process and production. Technology is defined in the Oxford dictionary as “the application of scientific knowledge for practical purposes, especially in industry” and “machinery and equipment developed from scientific knowledge”. Badiru (1996) described technology in manufacturing as “an involvement of high tech tools and processes in operations and manufacturing activities”. The petrochemical industry can be described as a wide network of different integrated production processes and operations. The outcomes of the petrochemical production process can also be reintegrated into raw materials for another process in a different plant. The exploitation of these materials can provide a wide range of other raw materials to be used and exploited in different industries. According to Bell (1990), petroleum feedstock, natural gas and tar represent the main materials within the petrochemical industry. The utilization of these materials can produce many different chemical products including ethylene, propylene, butylene, butadiene, benzene, toluene and xylene. Furthermore, these materials can be used to produce other important materials and products.

According to Bell (1990), the wide range of petrochemical materials and products requires different types of technologies and operational processes. Recognizing the most appropriate technologies and other requirements through effective planning is equally important. Producing a particular type of petrochemical product is dependent on several issues, such as the required production process, the feedstock quality, the technologies used and, most importantly, the type of materials and feedstock. Gary and Handwerk (1994) categorized the main petrochemical feedstocks as aromatics, olefins, and
paraffin/cycloparaffin compounds. These feedstocks and technologies used in production and processing are discussed below.

2.5.1 Aromatics

Aromatics or aromatic hydrocarbons (AH) include several compounds such as benzene ring. Other aromatic compounds used in the petrochemical industry include toluene, xylene (BTX) and ethylbenzene. These compounds are produced through catalytic reforming and technologies where their yield can possibly increase with the increase of reforming severity (Gary and Handwerk, 1994). A number of technologies can be used for the production and separation process of aromatics, for example Paramax technology by Axens (Axens, 2010).

2.5.2 Olefins

Olefins are hydrocarbon compounds, an unstable chemical material consisting of one carbon-to-carbon double bond. In addition, they can be affected by tendency, which makes these compounds very important as building blocks in the chemical and petrochemical industry (Gary and Handwerk, 1994). Furthermore, the production of olefins consists of fluid catalytic cracking in refineries and the most important production source for this is the steam cracking of liquefied petroleum gas (LPG), naphtha or gas oils. Several advanced technologies are available for the processing of olefins, such as ACO Technology from KBR and SUPERFLEX (KBR, 2010).

2.5.3 Normal paraffins and cycloparaffins

Paraffin hydrocarbon is a highly stable compound because it involves only single bonded carbon atoms. Normal paraffin compounds are available in large quantities in petroleum fractions and are recovered from light straight-run (LSR) naphtha and kerosene. On the other hand, the non-normal hydrocarbon components of LSR naphtha contain a larger octane level which makes it preferable for gasoline blending (Meyers, 1997). For the
production of normal paraffins and cycloparaffins, a number of advanced technologies can be used such as the ENSORB recovery process by ExxonMobil Chemical, or MOLEX by UOP (ExxonMobil, 2010; UOP, 2010).

2.6 Summary

The petrochemical industry has been targeted by the Saudi government as a strategically important sector. In addition, the development of a successful strategy for the petrochemical industry is seen as important for the country’s future economic growth, as well as its environmental and social well-being. To achieve competitiveness, the petrochemical companies in Saudi Arabia are encouraged to continue investing and adopting new technologies, expanding their activities and building joint ventures to add value to the industry. However, before going ahead with investments to implement new petrochemical technologies, an effective planning and decision-making process is required to ensure the investment decision is the right one and to avoid the possible risks that may lead to failure.

This chapter has presented an overview of the petrochemical industry in Saudi Arabia by reviewing the current status and the challenges that the industry faces. In addition, it has reviewed the importance of petrochemical materials and the related technologies that petrochemical projects use and implement to ensure successful investment. Investing in new technologies is a key element for petrochemical companies to achieve competitiveness and it requires planning to make the investment decision. This chapter will be followed by a literature review exploring the factors and difficulties that may impact the investment decision-making process.
Chapter Three
Factors influencing the investment decision
3.1 Introduction

Decision makers face difficulties in evaluating their organization’s ability to adopt new technologies. This section deals with the complexity of technology investment decisions and how several internal and external factors may affect the investment decision. These include environment, organization structure, operations, competitiveness and top management performance.

This chapter will review the importance of the company’s readiness in the investment decision-making process. The review will be made by looking at definitions of readiness and its related factors, and how these will affect the new technology investment decision. Being aware of the organization’s level of readiness can support decision makers in selecting the right investment.

3.2 The complexity of technology investment decisions

Advanced technologies supply firms with wide business opportunities and different ways to increase efficiency, lower costs, and improve the organization’s productivity (Basole and DeMillo, 2006). In the current competitive business environment, decision makers have to justify their decisions regarding technology investment and strategy (Rouse et al., 2000; Ward and Peppard, 2002). Organizations must evaluate their current situation and the position of technology, looking for possible gaps, recognizing the opportunities,
assessing the necessary technology, and selecting the right solutions that can bridge current and future gaps to meet their needs and business objectives.

Technology investment decisions are very complicated and difficult to make for many reasons, such as competitive pressures, organizational influences, customer requirements, and supplier forces. More importantly, making the technology investment decision can be difficult if the benefits and values of the technology cannot be identified (Sandee and Rietveld, 2001). The research will investigate the factors related to technology investment and how it will affect technology investment decisions.

3.3 Factors related to decision-making over technology investment

Investment in technology can be influenced by many different factors which can be difficult to control (Warren, 2004). Several researchers have identified factors that can impact the success of investment in manufacturing technologies, such as: the level of investment, context, culture within the organization, organizational strategy, structure, internal issues (experience and qualifications), external issues (government regulations, customer demands, technology type, suppliers) and the ability to plan effectively (Beaumont et al., 2002; Castrillon and Cantorna, 2005; Raymond, 2005; Raymond and Pierre, 2005; Small, 2006, 2007; Small and Yasin, 2003; Swamidass and Kotha, 1998). These factors will be categorized and discussed in depth below. Table 3.1 shows some of the factors related to technology investment, summarized from the literature review which is discussed in the following sections.
<table>
<thead>
<tr>
<th>Factors</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Environmental (internal and external) factors</strong></td>
<td>Organization's capability (Fillis et al., 2004; Tidd et al., 2001)</td>
</tr>
<tr>
<td></td>
<td>Customer requirements and demands (Berry et al., 2001; Premkumar and Ramamurthy, 1995)</td>
</tr>
<tr>
<td></td>
<td>Competition and globalization (Tidd et al., 2001)</td>
</tr>
<tr>
<td></td>
<td>Quality and availability of technology (Kwon and Zmud, 1987)</td>
</tr>
<tr>
<td></td>
<td>Suppliers issues (Berry et al., 2001; Premkumar and Ramamurthy, 1995)</td>
</tr>
<tr>
<td></td>
<td>Availability of external resources (Berry et al., 2001; Harenstam et al., 2006)</td>
</tr>
<tr>
<td><strong>Organizational factors</strong></td>
<td>Employee skills and readiness (Baldwin et al., 1996; Fillis et al., 2004; Warren, 2004)</td>
</tr>
<tr>
<td></td>
<td>Resources and funding (Wagner and Hansen, 2005)</td>
</tr>
<tr>
<td></td>
<td>Organizational design and structure (Bailey, 1993; Preece, 1995)</td>
</tr>
<tr>
<td></td>
<td>Strategic plan (Bailey, 1993)</td>
</tr>
<tr>
<td></td>
<td>Design of the work process (Preece, 1995)</td>
</tr>
<tr>
<td></td>
<td>Size of the firm (Preece, 1995)</td>
</tr>
<tr>
<td><strong>Factors related to top management</strong></td>
<td>Management attitudes and commitment (Foster, 2001; Rotchanakitumnuai and Speece, 2003)</td>
</tr>
<tr>
<td></td>
<td>Awareness and knowledge (Basu et al., 2002; Becker, 2001; Carpenter et al., 2004)</td>
</tr>
<tr>
<td></td>
<td>Management internal support (Kanji and Moura, 2001)</td>
</tr>
<tr>
<td></td>
<td>Benefit realization (Simpson and Docherty, 2004)</td>
</tr>
<tr>
<td></td>
<td>Align technology with business strategy (Carpenter et al., 2004)</td>
</tr>
<tr>
<td><strong>Operational factors</strong></td>
<td>Production processes (Kuan and Chau, 2001; Tidd et al., 2001)</td>
</tr>
<tr>
<td></td>
<td>Technologies (Palvia and Jackson, 1994; Rogers, 1995)</td>
</tr>
<tr>
<td></td>
<td>Data and information (Harenstam et al., 2006; Kuan and Chau, 2001)</td>
</tr>
<tr>
<td></td>
<td>Technical skills (Axtell et al., 2001; Baldwin et al., 1996; Fillis et al., 2004)</td>
</tr>
<tr>
<td></td>
<td>Human issues and labour problems (Axtell et al., 2001; Baldwin et al., 1996; Fillis et al., 2004)</td>
</tr>
</tbody>
</table>

Table 3.1: Factors related to technology investment summarized from the literature review

### 3.3.1 Environmental (internal and external) factors

Several authors have identified the impact of environmental factors on technology investment decision-making. External and internal factors can affect the success of the technology investment. Environmental factors include the organization’s capability in dealing with the current market trend, customer requirements, competition and globalization (Tidd et al., 2001). Other factors such as the overall conditions of the organization’s infrastructure, the working conditions and the work instructions that the firm is using, will have important effects (Harenstam et al., 2006).
On the other hand, several researchers have recognized that some external factors may also have an impact on technology investment. According to Premkumar and Ramamurthy (1995), factors such as suppliers, competitive pressure, customer requirements and market trend could influence the decision to adopt new technologies. The availability of the resources and technology implementation requirements within the local market are two of the external challenges (Kwon and Zmud, 1987). Therefore, it is important to have strong communication with vendors to ensure good access to new technology (Berry et al., 2001).

### 3.3.2 Organizational factors

Organizational factors also play a significant role in the technology investment decision. According to Warren (2004) the employees’ qualifications and knowledge can be considered one of the important factors. Qualifications include the skills, knowledge and confidence needed to ensure successful adoption and implementation of technology. For that reason, education is a key element because not only will it have an impact on technology investment it will also improve people’s performance, leading to more flexibility and the better use of technology (Fillis et al., 2004). In some cases, gaining benefits from investing in new technologies requires fundamental changes in the organizational structure and human behaviour (Preece, 1995). For example, the organizational structure plays an essential role and it may have an effect on the performance of advanced manufacturing technologies. Bailey (1993) has reported some factors influencing investment in advanced manufacturing technology such as the overall strategic plan, organizational design, the design of the work process, and the skills and qualifications of the employees.

Employees with poor skills (in particular technical skills) is one of the common problems that any organization will face during the implementation of advanced technology. Also, it may be difficult to find the right skills in the market at the right time. Another issue related to skills problems is that of training difficulties, for example organizing training
sessions and courses. Training is one of the important elements to ensure high quality performance within the organization (Baldwin et al., 1996).

Several researchers reported that the size of the firms might have a huge influence on the investment decision of new technologies (Palvia and Jackson, 1994; Rogers, 1995). Larger-size firms are able to maintain better control of the resources which will support the investment in new technologies. Furthermore, better control of the financial resources to support the adoption of new technologies may also be required (Wagner and Hansen, 2005).

3.3.3 Operational factors

Investment decisions can be affected by the nature of the organization’s operations (Tidd et al., 2001). Many operational factors can have an impact on the organization’s decisions, depending on what the firm produces and what the production processes are. Other different factors related to the operations, such as the changes, demands and regulations, might affect the work environment (Harenstam et al., 2006). Investing in new technologies may require the firm to change the work environment and the working conditions to improve performance. Introducing new technology may also require changes to the processes, roles, responsibilities and applications (Kuan and Chau, 2001). In addition, the human issues and labour-related problems are two of the major factors that must be considered to achieve the successful adoption of technology (Axtell et al., 2001; Baldwin et al., 1996).

3.3.4 Top management related factors

In general, the top management in any type of organization plays a major role in planning and supporting the activities and business processes to add value to the organization’s performance (Kanji and Moura, 2001). Top management commitment is one of the important elements/factors to ensure and control the quality of performance within the
organization (Foster, 2001). Top management is responsible for controlling many factors such as organizational environment, values and behaviours within the organization. These factors are important in driving the organization to achieve successful performance (Dale, 1999).

The attitudes and behaviour of managers in the organization are two of the factors that possibly will have an influence on the technology investment decision-making process (Rotchanakitumnuai and Speece, 2003). For instance, managers who are very sensitive and careful toward changes or new investments are more likely to show signs of unhelpful attitudes toward their technology investment, this factor probably leading to unsuccessful investment (Basu et al., 2002). Investment in technology is expected to create competitive advantage and innovation by improving the performance, quality, flexibility, and efficiency of the business process (Gilbert et al., 2004). Realizing the benefit of technology investment is one of the decision maker’s responsibilities (Simpson, 2004). Poor planning for realizing the benefit of investment may create a major concern about the selected technology and its value to the organization.

The organization’s ability to adapt and use new technology is one of the biggest challenges that an organization’s executives have to think about before making the decision to use advanced technology. Therefore, realizing the technology potential requires the understanding of its application, requiring knowledge of the technology from the organization’s top management and a readiness from the employees (Becker, 2001). The top management is also responsible for building strong external relations to support the organization and for continuous development and improvement within it (Carpenter et al., 2004). Any important decision within organizations must be made by executives and specialist workers. Decisions related to changes in design and development, planning, production and investment, are very critical and could affect the firm’s strategic objectives. Thus, these decisions require a high level of awareness and knowledge from the top management to avoid any risk and to ensure successful changes within the organization (Carpenter et al., 2004).
3.4 Company readiness and the technology investment decision

According to the Oxford dictionary, “readiness” is defined as “the state of being fully prepared for something”. With regard to investments, SQW (2004) reported that poor readiness for an investment could be a result of several factors, such as inadequate awareness of the available financing options, a failure to understand the needs of investors, and the poor quality and presentation of business strategy and plans.

In this research, readiness is defined as “the readiness and ability of petrochemical manufacturing companies to successfully invest in and use an advanced technology”. It is important for petrochemical manufacturing companies that propose to invest in advanced manufacturing technology to undertake an in-depth analysis of their investment readiness and operations to ensure a productive and successful implementation of the selected technologies. Therefore, they need to assess and measure their readiness levels.

3.4.1 Investment readiness

The importance of identifying the organization’s readiness and abilities in relation to investment has been reported by a number of researchers (Feeney et al., 1999; Mason and Harrison, 2001; Wright et al., 2006). According to Feeney et al. (1999) and Wright et al. (2006), the concept of investment readiness is based on a number of factors that determine investment maturity level, such as business planning, business modelling, market connection, establishment of management practices, specialist equipment, and the utilization of consultants. On the other hand, internal factors such as human resources issues, operational capabilities, financial resources and top management support are very important elements in increasing companies’ investment readiness and maturity level (Christensen, 2007). In addition, investment readiness is based strongly on development trends and issues which require companies to make use of expertise and consultants to identify the difficulties and gaps in investment (Mason and Harrison, 2001).
3.4.2 Operational system readiness

The amount of manufacturing development and growth over the last century raised expectations for further development in the 21st century. Tetlay and John (2009) described the 21st century as “The Systems Century” because of the increasing complexity and high integration of technological product services. As a result of this development, companies and organizations face a significant challenge in assessing their systems maturity and their readiness to operate successfully. However, because of the interest amongst many companies to assess their readiness and maturity, a number of readiness measurement tools and systems have been developed, such as Technology Readiness Level (TRL), System Readiness Level (SRL), Manufacturing Readiness Level (MRL), Integration Readiness Level (IRL), and other systems for different sectors and applications. These concepts will be reviewed and discussed in the following sections.

3.4.3 Technology Readiness Level (TRL)

According to Parasuraman (2000), “Technology readiness” is a concept to explain the distinctive behavioural process behind the adoption of technology-based products and service. Technology Readiness Level (TRL) is a measurement system that was initiated by the National Aeronautics and Space Administration (NASA) in the 1980s and developed later by the Department of Defense (DoD) (Bilbro, 2009; Cornford and Sarsfield, 2004; Nolte et al., 2004; Smith, 2004). The TRL tool has been developed and used by many world class companies and agencies in different sectors around the world. The TRL tool aims to evaluate and assess the technological maturity and readiness with regard to materials, components and devices. Moreover, the TRL tool has been defined by many organizations and agencies based on their own use and applications (Tetlay and John, 2009). The Department of Defense (DoD) and the National Aeronautics and Space Administration (NASA) definitions are the most common and used definitions, and are described in Table 3.2.
<table>
<thead>
<tr>
<th>Technology Readiness Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Basic principles observed and reported</td>
<td>Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Examples might include paper studies of a technology's basic properties.</td>
</tr>
<tr>
<td>2. Technology concept and/or application formulated</td>
<td>Invention begins. Once basic principles are observed, practical applications can be invented. Applications are speculative and there may be no proof or detailed analysis to support the assumptions. Examples are limited to analytical studies.</td>
</tr>
<tr>
<td>3. Analytical and experimental critical function and/or characteristic proof of concept</td>
<td>Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.</td>
</tr>
<tr>
<td>4. Component and/or breadboard validation in laboratory environment</td>
<td>Basic technological components are integrated to establish that they will work together. This is relatively &quot;low fidelity&quot; compared to the eventual system. Examples include integration of &quot;ad hoc&quot; hardware in the laboratory.</td>
</tr>
<tr>
<td>5. Component and/or breadboard validation in relevant environment</td>
<td>Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so they can be tested in a simulated environment. Examples include &quot;high fidelity&quot; laboratory integration of components.</td>
</tr>
<tr>
<td>6. System/subsystem model or prototype demonstration in a relevant environment</td>
<td>Representative model or prototype system, which is well beyond that of TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high-fidelity laboratory environment or in a simulated operational environment.</td>
</tr>
<tr>
<td>7. System prototype demonstration in an operational environment</td>
<td>Prototype near, or at, planned operational system. Represents a major step up from TRL 6, requiring demonstration of an actual system prototype in an operational environment such as an aircraft, vehicle, or space. Examples include testing the prototype in a test bed aircraft.</td>
</tr>
<tr>
<td>8. Actual system completed and qualified through test and demonstration</td>
<td>Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.</td>
</tr>
<tr>
<td>9. Actual system proven through successful mission operations</td>
<td>Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. Examples include using the system under operational mission conditions.</td>
</tr>
</tbody>
</table>

Table 3.2: Technology Readiness Levels in the Department of Defense (DoD)  
(Source: DoD, 2006, Defense Acquisition Guidebook)
3.4.4 Manufacturing readiness

Manufacturing readiness is the ability and maturity to exploit and control the manufacturing, production, quality assurance and industrial operations to reach satisfaction and better operational potentials and the ability to achieve main goals and objectives (JDMTP, 2009). Manufacturing readiness also means the ability to achieve optimum performance as well as reduced costs for developing, producing, acquiring and operating systems within the company. Measuring the manufacturing readiness is an essential step in understanding the organization’s operational status. However, few researchers and studies have examined the area of operational and manufacturing readiness. Manufacturing Readiness Level (MRL) is a concept that was designed and developed by a joint DoD/industry working group with support from the Joint Defense Manufacturing Technology Panel (JDMTP). The aim of designing the MRL was to build a measurement tool to assess and determine manufacturing maturity, risk and readiness. MRLs contain ten different readiness levels and they were developed with different types of systems to enable comparison with the Technology Readiness Levels (TRLs) for better use and understanding.

For decision makers, MRLs can be considered an effective tool in measuring the manufacturing maturity and risks of the technology and development (JDMTP, 2009). In addition, MRLs can help decision makers to understand and determine the current manufacturing level by taking into account the technologies, products, and processes that are being considered to meet DoD requirements. However, MRLs have their own dimensions and threads to achieve successful manufacturing. MRL threads allow the decision makers to gain a detailed understanding of manufacturing readiness and ensure stability from one level to the next. MRLs fall into nine threads as Table 3.3 shows.
<table>
<thead>
<tr>
<th>Threads</th>
<th>Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology and the Industrial Base</td>
<td>Requires an analysis of the capability of the national technology and industrial base to support the design, development, production, operation, uninterrupted maintenance support of the system and eventual disposal (environmental impacts).</td>
</tr>
<tr>
<td>Design</td>
<td>Requires an understanding of the maturity and stability of the evolving system design and any related impact on manufacturing readiness.</td>
</tr>
<tr>
<td>Materials</td>
<td>Requires an analysis of the risks associated with materials (including basic/raw materials, components, semi-finished parts, and sub-assemblies).</td>
</tr>
<tr>
<td>Cost and Funding</td>
<td>Requires an analysis of the adequacy of funding to achieve target manufacturing maturity levels. Examines the risk associated with reaching manufacturing cost targets.</td>
</tr>
<tr>
<td>Process Capability and Control</td>
<td>Requires an analysis of the risks that the manufacturing processes may not be able to reflect the design intent (repeatability and affordability) of key characteristics.</td>
</tr>
<tr>
<td>Quality Management</td>
<td>Requires an analysis of the risks and management efforts to control quality and foster continuous improvement.</td>
</tr>
<tr>
<td>Manufacturing Personnel</td>
<td>Requires an assessment of the required skills and availability in required numbers of personnel to support the manufacturing effort.</td>
</tr>
<tr>
<td>Facilities</td>
<td>Requires an analysis of the capabilities and capacity of key manufacturing facilities (prime, subcontractor, supplier, vendor, and maintenance/repair).</td>
</tr>
<tr>
<td>Manufacturing Management</td>
<td>Requires an analysis of the orchestration of all elements needed to translate the design into an integrated and fielded system (meeting Program goals for affordability and availability).</td>
</tr>
</tbody>
</table>

Table 3.3: MRL dimensions and threads  
(Source: DoD, 2009, Manufacturing Readiness Assessment (MRA) Deskbook)

3.5 Technology alignment with the business

Alignment between technology and the organization is important to firms for many reasons, and is well recognized by many researchers and publications. Gagnon and Haldar (1997) described alignment as an important aspect that organizations must consider for technology selection and investment. The alignment between technology and the organization must take into account the goals, competitiveness, long-term viability
and financial viability of the technology. In addition, the selected technology must be in line with the business objectives, strategy, competitiveness and profitability that the organization aims to achieve. Teo and King (1996) reported that alignment between the technology and the business units is an important step in ensuring the success of the implementation of that technology. According to Lederer and Mirani (1993), alignment between the organization’s processes and structural objectives should be considered during investment planning, in order to support such decisions. Poor alignment between the organization and the technology used will have a negative impact on the organization’s performance (Hicks, 2007). The technology used must be able to align with all the units that are involved within the organization (Laudon and Laudon, 2003).

Effective alignment between the technology and the organization’s business strategy is essential to increase competencies and to achieve the organization’s strategic objectives (Phaal et al., 2001). However, achieving the required alignment is considered to be a critical task for organizations. According to Gokhale and Myers (2007), before making any decision relating to technology, companies need to consider many factors that might play a critical role in achieving the required alignment. These factors include time, financial support, market position and the state of technology in the market. Therefore, investing in technology must take into account the alignment between the technology and organization during the decision-making process to ensure a successful final decision. In addition, according to Bishop and Scott (2000), creating alignment of technology is difficult because of the need for strategic planning for technology. This difficulty is related to inadequacies in the strategic visions and long-range planning required for technology-product development, such as aligning technology strategies with business strategies and decision-making processes, a lack of understanding of technology and its roles among corporate strategic planners, and a failure to identify the critical success factors of a company’s technology activities. Therefore, technology alignment with business is important for the success of the project.
3.6 Summary

Chapter three reviewed and discussed the factors that may affect investment decisions relating to technology in general, and the importance of taking account of these factors in order to achieve the right investment decision. The review covered internal and external factors and issues that could affect the organization’s plans and processes for investing in technologies. Factors related to environments, operations, production, top management and staff are seen as important issues that must be considered before an appropriate technology investment decision can be taken. In addition, the chapter also discussed the importance of the organization’s readiness and its relationship with investment decisions. It has been found that readiness has a wide impact on the organization’s capabilities to conduct the investment successfully. It has also been observed that manufacturing organizations should consider several aspects such as investment readiness, financial readiness, manufacturing readiness and technology readiness.

In addition, the alignment of the technology with the organization is considered a very significant element that decision makers must take into account during the decision-making process. Alignment between the technology and the organization is crucial in setting and achieving the business objectives and achieving the level of competitiveness and profitability that the organization is expecting from the technology. Thus, the review of the related literature on technology investment aims to address the research aim and objectives by providing an understanding of the possible factors and their impacts on the investment decision. Furthermore, the review of the related literature is intended to support the questionnaire design to provide an in-depth understanding of decision-making processes, factors and the possible difficulties that could affect technology investment decisions. The results of the literature review have also contributed to the analysis of the results of the studies conducted for this research.
Chapter Four

The impact of investment justification and benefit realization on the technology investment decision
Chapter Four

The impact of investment justification and benefit realization on the technology investment decision

4.1 Introduction

Chapter three established the review of the critical factors that affect technology investment and the importance of understanding the readiness of the organization to invest in technology. To provide a wider review to address the research objectives, the purpose of this chapter is to explain the concepts behind two important areas that play vital roles in determining and understanding the benefits of the technology. This chapter also discusses the importance of justifying the investment in new technology to gain a better vision of the technology benefits and capabilities. The literature from both areas is important in understanding and realizing the benefit of technology investments. The chapter will review the existing investment justification approaches and techniques and how they can support the selection of the right technology.

This chapter also aims to examine the impact of benefit realization approaches in the context of technology investment decisions, and will discuss the importance of benefit realization and its role in technology investment, aiming to investigate how management can ensure that investments made in technology are effective. This also will be supported by a review of a number of models and frameworks that are applied to benefit realization and management.
4.2 Investment justification and technology investment decisions

It is widely recognized that innovative manufacturing technologies play a significant role in sustaining and maintaining organizational competitiveness. Benefits include: improved manufacturing processes, reduced labour, reduced costs, improved product quality, greater flexibility and improved performance (Boyer et al., 1997; Chan et al., 2001; Das and Jayaram, 2003; Kotha and Swamidass, 2000; Laosirihongthong and Paul, 2004; Machuca et al., 2004; Sun et al., 1999; Tan et al., 2006). However, investment in manufacturing technology requires careful planning to avoid any risk or any unexpected problems during the implementation process (Chan et al., 2001).

Planning is an important stage for any investment, and this needs in-depth analysis from various perspectives. Investment in advanced manufacturing technology, aimed at improving competitive advantage, requires careful justification (Gurumurthy and Kodali, 2008). Justifying technology investment is a major concern for many companies and organizations, and is an important step in achieving business objectives. Justifying the investment in technologies can be considered as a competitive tool and a clear policy to support the organization’s strategy. Investment justification can also be a tool for convincing business executives of cost and benefits issues (Kodali and Sangwan, 2004).

According to Small (2006), to ensure that investment is well justified strategically and operationally, it is important to select and use the most appropriate justification methods and techniques. Therefore, the justification should take into account the overall situation of the organization and the technology used. The following steps are part of investment justification (Small, 2006):

- Recognizing the benefits that need to be achieved;
- Identifying what type of technology can support the attainment of these benefits;
- Taking into account the required organizational infrastructure changes that are necessary to achieve successful implementation of the technology.
It is necessary to establish a clear strategy and process for investment justification. Krar (2000) identifies some points that can help to justify investments:

- The value of consistent and better product quality;
- The cost of scrap, rework, and large inventories;
- The cost of missed delivery dates, lost contracts and shrinking market share;
- The value of greater flexibility and the ability to respond quickly to market changes;
- The cost of not being able to hold existing markets or open new markets due to a lack of competitive equipment or the capacity of the company;
- The value of increased productivity and reduced lead-time;
- The cost of product and prototype development, engineering changes, work-in-progress, inventory, and inefficient use of equipment and facilities.

4.3 Difficulties with justifying new technology investment

Justifying the investment from different angles is one of the important activities for technology investment decision planning (Small and Chen, 1995). At present many manufacturing companies and organizations still have difficulty in identifying an investment justification process. This is due to a poor understanding of, and lack of information for, the management of this complex problem (Canada and Sullivan, 1989). A number of research publications have reported that justifying investment in technology is a difficult matter for numerous organizations because of the many intangibles and non-financial benefits that are inherent during technology implementation (Irani, 1999; Irani et al., 1999).

In the literature, several researchers have reviewed and categorized the project justifications and selection techniques and methods, including Freeland and Schmidt (1992), Cooper and Zmud (2001), and Hall and Nauda (1990). Ghasemzadeh and Archer (2000) claimed that some of these techniques are difficult to use and apply, for several reasons, including: (1) they focus only on limited issues; (2) they are difficult to apply
Many justification techniques and approaches are difficult to use because they are based on past performance and past market trends. Techniques and approaches such as Standard Cost methodologies are based on the past manufacturing environment (Krar, 2000). Several methods and techniques such as return on investment (ROI), internal rate of return (IRR), net present value (NPV) and Analytic Hierarchy Process (AHP) are used in order to make the investment decision (Gurumurthy and Kodali, 2008). Table 4.1 summarizes the use of each method.

<table>
<thead>
<tr>
<th>Method</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AHP</strong></td>
<td>AHP is a decision-making tool to assist in dealing with complex, unstructured and multi-attribute issues. According to Saaty (1980), using the AHP method involves three steps: 1) design of hierarchy, 2) the prioritization procedure, and 3) calculation of results</td>
</tr>
<tr>
<td><strong>NPV</strong></td>
<td>NPV is considered a central tool in discounted cash flow (DCF) analysis. In addition, NPV can be used as a tool to help decision makers identify the time value of money to evaluate long-term projects. Also, it can be used for capital budgeting. Furthermore, NPV can also be applied to measure the excess or shortfall of cash flows (Grier and Nagalingam, 2000)</td>
</tr>
<tr>
<td><strong>IRR</strong></td>
<td>IRR is a useful indicator of the efficiency, quality, or finance of an investment. The IRR is also a tool that is used in capital budgeting to measure and compare the economies of investments (Mian, 2002)</td>
</tr>
<tr>
<td><strong>ROI</strong></td>
<td>Return on Investment (ROI) is a financial tool that can be used to measure the efficiency and effectiveness of an investment made by an organization. This can be done by evaluating several issues such as the business impact of the investment and the intangible benefits (Phillips, 1994)</td>
</tr>
</tbody>
</table>

Table 4.1: Various methods used to make the investment decision

In many manufacturing companies, before any investment is approved, an investment justification report must be presented and accepted by decision makers. Primrose (1991) reported that industry’s view and understanding of investment justification was as a
budgetary process that supports decision making on a proposed project or investment. Therefore, top management or decision makers may find that justifying the investment is difficult, and requires them to put extra effort into investigating and examining all aspects of the investment (technical, financial and strategic).

Many approaches and techniques are available to justify investment in manufacturing technologies. Most of these cover three important aspects: economic, analytic and strategic. Figure 4.1 shows an updated version of the classification of investment justification techniques (Chan et al., 2001). The literature shows that investment justification approaches can be grouped into the following three categories (Chan et al., 2001; Small, 2006; Small and Chen, 1997):

4.3.1 The economic or financial approach

The economic or financial approach tends to be basic and clear, and has been used widely within many industries. The economic approach normally focuses on providing financial analysis and justification for an investment. This can be done using a number of available tools and techniques, such as discounted cash flow (DCF), net present value (NPV), payback period (PP), return on investment (ROI), break-even analysis and internal rate of return (IRR). Most of these techniques are commonly used by decision makers and managers to evaluate financial aspects, in order to provide economic justification for an investment or project. Many researchers agree that using such economic techniques can support an investment decision, but decision makers may not make the best justifications when some organizational factors are taken into consideration (Chan et al., 2001). In many cases, economic justification techniques give a clear result, but this result may be misleading when a short payback time or high discount rates are applied. To avoid some of these problems, it is important to apply some analytic and strategic techniques to obtain better justifications (Hynek and Janeèek, 2007).
4.3.2 The strategic approach

Strategic justification approaches focus more on how businesses are managed than on technical issues. At the same time, it is possible to link strategic justification with economic and analytic justification methods. Using strategic justification approaches can provide decision makers with many advantages because they link with the business objectives of the company. Strategic justification approaches focus more on how to achieve business goals, and on how to acquire competitive advantages (Raafat, 2002).

Chan et al. (2001) identified some questions that can provide strategic justification for new technology. These are as follows:

1. Will the new technology enable a manufacturing organization to satisfy its targets for cost, performance, quality, delivery, flexibility and innovation?
2. Does the proposed technology fulfill the organization’s missions and strategies?
3. Does the new technology provide any unnecessary functions?
4. Does the new technology fit the current manufacturing environment? If alterations are needed to fit the technology to the environment, what alterations are required? What problems will be faced? What will be the impact on the other decision areas?
5. How many potential benefits has the organization gained from previous investments in new technologies?

4.3.3 The analytic approach

Analytic justification approaches focus more on evaluating non-financial (and intangible) aspects. They can be more difficult to use than strategic and economic techniques, but using an analytic method can give a more realistic appraisal by taking more factors into consideration. This can offer a clearer picture of all related aspects (Meredith and Suresh, 1986). Different methodologies and techniques can be used to identify analytic
justifications, such as Analytical Hierarchy Process (AHP) models, mathematical analysis tools and risk analysis tools. These methods consist of some traditional techniques and some risk analysis tools, and aim to give non-financial and intangible justifications. According to Abdel-Kader and Dugdale (2001), consider the need to understand the non-financial factors in technology evaluations, using the mathematics of the analytic hierarchy process and fuzzy set theory through a data analysis. Methods such as the AHP, real options pricing, and simulation are used to give a more systematic evaluation of investments in technology by addressing traditional tools’ inability to comprise the qualitative benefits of technology such as increased flexibility.

4.3.4 Comparison of approaches

Many managers who use investment justification techniques may not realize the advantages and disadvantages of these methods. Karsak and Tolga (2001) emphasize the nature of each method and their advantages and disadvantages for investment decision-making (see Table 4.2). For example, justifying the investment economically by using the payback method can be an easy way to collect the required data. However, the payback method does not provide justification about the strategic and non-economic benefits. In addition, the disadvantage of economical methods such as return on investment (ROI) is that they cannot support the investors to realize the benefits such as quality and flexibility. On the other hand, although strategic justification techniques can be used with less technical data, analytic methods require more data and more complexity than the economic analysis, which is considered as an disadvantage.
<table>
<thead>
<tr>
<th>Techniques</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Payback method</td>
<td>Ease of data collection</td>
<td>Do not take into account strategic and non-economic benefits</td>
</tr>
<tr>
<td>Return on investment</td>
<td>Intuitive appeal</td>
<td>Consider a single objective of cash flows, and ignore other benefits such as quality and flexibility</td>
</tr>
<tr>
<td>Discounted cash flow techniques</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical importance</td>
<td>Require less technical data</td>
<td>Necessity to use these techniques with economic or analytic ones since they consider only long-term intangible benefits</td>
</tr>
<tr>
<td>Business objectives</td>
<td>Use the general objectives of the firm</td>
<td></td>
</tr>
<tr>
<td>Competitive advantage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research and development</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scoring models (Analytic Hierarchy Process (AHP))</td>
<td>Uncertainty of the future and multiobjectivity can be incorporated</td>
<td>Require more data</td>
</tr>
<tr>
<td>Mathematical programming</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Integer programming</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Goal programming</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data Envelopment Analysis (DEA)</td>
<td>Subjective criteria can be introduced in the modelling phase</td>
<td>Usually more complex than the economic analysis</td>
</tr>
<tr>
<td>Stochastic methods</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fuzzy set theory</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4.2: Justification methods for advanced manufacturing technologies (Source: Karsak and Tolga, 2001)
NPV
Strengths: NPV is considered to be an easy method to apply, particularly in measuring and evaluating long-term investments. The NPV method helps decision makers to vary discount rates and measure the time value of money (Bhushan and Ria, 2004).

Weaknesses: the use of the NPV method alone without any support from other methods can not help in making a decision as it can not identify the exact value of the investment and possible risks that are linked with the size of the investment. In addition, the NPV method is difficult to use in identifying the discount percentage. According to Dos Santos (1991), the NPV method does not properly take into account management flexibility.

IRR
Strengths: unlike the NPV method, IRR does not need a calculation of discount rate. The IRR method can help decision makers to compare different sizes of investments across different investments (Bhushan and Ria, 2004).

Weaknesses: the use of IRR in some cases may lead to misleading results from an unrealistic assumption of the profits. In addition, the IRR method is difficult to use as it involves an iterative process. Also, IRR is subject to too many differences and limitations to make it a preferred approach (Poulin and Caruso, 1993).

According to Milis (2009), based on Apostolopoulos and Pramataris (1997), Brealey et al. (1995), and Manigart and Ooghe (1994), IRR also has the following disadvantages:

- The result of IRR is a percentage. This makes it difficult to compare services that differ substantially in size and outcome. Services can vary substantially in terms of granularity and functions offered.
- If the IRR differs substantially from the cost of capital, it will become difficult to compare investments in services with a different time pattern.
• When this technique is used as a selection tool for mutual exclusive services, risks are not accounted for. It lacks the possibility of entering risk-levels into the selection. This is a major disadvantage, especially when used in a services architecture where levels of future use are often highly uncertain.

Payback
Strengths: the payback method is one of the easiest and most fixable economic justification methods to apply. The payback method gives a clear picture about the possible risks by separating long-term investments from short-term (Bhushan and Ria, 2004).

Weaknesses: the payback technique may not give decision makers clear information about the profitability of the investment, as it does not take into account all the cash flows after the breakeven period. In addition, the payback technique does not consider the time value of money. Lim (1994) described the payback method as an ad hoc approach which is useful for communicating the results of investment analysis, but not for the analysis itself.

ROI
Strengths: the ROI method is one of the useful justification methods that can be used in comparing short-term investments with similar patterns of return (Bhushan and Ria, 2004).

Weaknesses: unlike the other methods and techniques, changing the time period of investment and returns may change significantly the estimation of the ROI. Moreover, the ROI does not take into account the possible risks and magnitude of the current investment. In addition, it doesn’t give an estimation of the opportunity cost of capital (Bhushan and Ria, 2004).
4.4 Top management involvement and justifying the investment

There are many evaluation approaches available for decision makers to justify their investments. The effective use of these approaches requires experience and knowledge, as well as readiness from the decision makers’ side. It might be difficult for decision makers to take into account all relevant criteria and factors because of the large amount of information required (Deng, 1994). Therefore, managers and decision makers throughout the organization must ensure that all resources are available for a particular investment or project. Also, it is necessary for managers to have experience and knowledge, as well as readiness, to produce better investment justifications. The lack of these elements may lead to managers facing some difficulties with the following (Gunasekaran et al., 2001):

- Identifying what their competitors are doing with technology, and how they are using it;
- Determining whether the organization can stay competitive, with or without technology;
- Appraising how the investment in technology will drive the organization to obtain better performance and competitiveness.

To gain a better justification of technology investment, managers and decision makers should try different analytic, economic and strategic investment appraisal approaches and methodologies. However, it is not easy to use all of these methods because there are many relevant issues and factors that must be taken into consideration, such as the process of implementing the technology. This may force the planners to think again about available justifications (Irani, 1999; Irani et al., 1999).
4.5 Importance of technology selection

The term “technology” is described by Steele (1989) as “capabilities that an enterprise needs in order to provide its customers with the goods and services it proposes to offer, both now and in the future”. The definition expresses the importance of the technology to the success of any business or project. On the other hand, to ensure the effectiveness of the technology, the selection of the technology and its process and criteria are important elements which will support the company in gaining a more competitive performance, product, and service, and more effective selection. The selection of new technologies can be a decisive issue for companies, due to several matters that may affect their capability to select the most appropriate technology. As a result, there is a need for effective planning and a methodology to take into account all possible factors to ensure a successful technology-selection decision.

Technology selection is concerned with deciding the most appropriate technology from a number of choices. Gregory (1995) defines technology selection as “involving the choice of technologies that should be supported and promoted within the organization”. The criteria for a “best” technology may be different, depending on the company’s needs and requirements. The selection of the most appropriate technological solution can be considered as an important element in driving the organization to achieve competitive advantage. However, the selection of technologies can be considered to be one of the most challenging and difficult decision-making areas. The goal of selecting the right technology is to obtain new know-how, components, and systems that will drive the company to support its products, services and processes, in order to be more effective and to improve performance (Reza, 2006).

Gregory (1995) reported that technology selection should be linked with R&D management, skills and capabilities, and with new investment and projects. Lamb and Gregory (1997) proposed that technology selection involves “gathering information from various sources about the alternatives, and the evaluation of alternatives against each other or some set of criteria”.
4.5.1 Factors to consider in technology selection

Many factors may affect the process of selecting technology for a particular investment. These factors may have a negative or positive impact on technology selection. Yap and Souder (1993) reported that organizations should consider a number of characteristics in any technology selection model. These include:

- The critical success/failure factors for technical and non-technical issues (risk);
- The funding history of the technologies within the company;
- The resources needed to improve and develop the technology;
- The level of advantages that technologies contribute to established projects or investment;
- The age and current life-cycle stage of the technologies;
- The selected technology must align with the business process and the nature of the company.

4.5.2 Technology licensing

Technology licensing has been used as a strategic tool for achieving competitive advantage by many companies and firms across many industries over the past decades (Arora et al., 2001; Burpitt & Rondinelli, 2004). McDonald and Leahey (1985) described technology licensing as a contractual agreement in which an organisation sells rights to use technology in the form of patents, processes and technical know-how to another firm for payment of royalties and/or other compensation. Technology licensing has a positive impact on a company’s performance by offering a range of benefits internally and externally (Arora et al., 2001; Burpitt & Rondinelli, 2004; Gambardella et al., 2007). According to Lichtenthaler (2007), technology licensing can provide two important strategic benefits: strengthening the company’s product market position and improving the company’s technological position. In addition, Sen and Rubenstein (1989) claimed
that companies prefer to obtain the required technology through technology licensing instead of other ways, for the following reasons:

- reducing risk in product and process development
- saving resources in companies with developing the technology in-house
- gaining time by increasing the speed of entry into the market
- gaining advanced know-how quickly
- ability for in-house development
- in-house work reaching a stage where it is worthwhile obtaining a license
- up-grading in-house technical skills
- existence of more reliable estimates of probable commercial and technical success
- availability of a proven cost-saving process
- adoption of industry product standards providing compatibility to the customer
- In-house ability better suited to improving existing technology rather than creating own know-how.

Transferring and licensing the technology can be conducted through different types of agreements, such as patents, technology alliances, production licenses, new firm start-ups, commercial agreements, in-house formal R&D, contract R&D, strategic R&D partnerships, acquisition of the technology, technology absorption, purchasing, joint venture, acquisition of a company with the knowledge, and foreign direct investment.

Licensing and transferring the technology may incur many issues and difficulties according to several researchers (Arora et al., 2001; Chesbrough, 2006; Hamman and Mittag, 1986; Lichtenhaler & Ernst, 2007; Lichtenhaler et al., 2010; Teece, 1994). Identification of the most appropriate licensing opportunities is one of the major issues in technology licensing (Chesbrough, 2006; Lichtenhaler & Ernst, 2007). In addition, technology licensing can be considered as more difficult and complex than commercialising products and services (Brockhoff, 1992).

Managerial difficulties were also found to be issues that affect technology licensing and transfer (Arora et al., 2001). According to Escher (2003), many companies face difficulties in managing their technology transfer and licensing activities, which may affect their realisation of the benefits from the technology. In addition, identifying the financial benefits of a particular technology before licensing and introduction of the
product is very difficult. Also, measuring the financial performance, the timing of licensing and evaluating the technology life cycle, were considered as major concerns in technology licensing (Ford and Ryan, 1981).

The relationship and negotiations between the licensor and the licensee may also be problematic. Kollmer and Dowling (2004) reported that several issues could be barriers in achieving a deal in licensing the technology, issues such as timing, the type of licensee, the specifications and features of the licensed technology, the range of the agreement, limitations and restrictions of the license, and benefit share arrangements. The limitation of technology providers on the market and the difficulty in finding the right partners, were also found to be important issues that affected technology licensing.

In technology licensing or transfer, many researchers considered collaboration and joint venture as an effective method that depends on several factors, such as collaboration agreements (Anand and Khanna, 2000; Johnson et al. 2004). According to Nieto and Santamaria (2007), collaboration agreements are considered as a way of developing and acquiring technological solutions, but it follows that the type of technological partner is a crucial and critical issue. Therefore, the types of partners and their collaboration strategies can determine how technology licensing, learning, transferring and sharing knowledge are managed and what level of innovation can be achieved (Whitley, 2002). Collaboration also plays an important role in both product and process innovation (Miotti and Sachwald, 2003). Therefore, a firm’s capabilities level in managing the collaboration can reflect the success of the alliance (Johnson et al., 2004).

The adopted strategy in technology licensing and collaboration is also a critical factor to the success of transferring the technology. Many firms adopt a close strategy in collaboration strategy because of their intent to protect patents and to gain the most return from licensing their technology (Barney, 1991). Chesbrough (2007) points out the importance of the degree of openness as a major issue in licensing strategies. In addition to the adopted strategy, limited licensing experience is a barrier to the success of technology transfer (Hutzschenreuter and Kleindienst, 2006).
Licensing the technology could be very complicated because of the expected competition between companies to acquire a particular type of technology with a single holder. According to Katz and Shapiro (1986), a single technology holder may have the opportunities to increase the strength of the production, competition and innovation. In addition, the level of competition created by the licensing could impact on the technology holder’s strategy, as licensing could also financially affect the licensors in that a licensee who acquired the new technology may produce products which would enable competing with its technology provider in the product market (Kim, 2009). As a result, technology licensors were careful to license their technology to other companies in the same field, and this helped them to control competitive advantage (Contractor, 1981; Kim, 2009). According to Rockett (1990), technology owners are very keen and careful in choosing their licensing partners as licensing the technology to a weak firm could cause a limitation within the market and deter entry by a stronger competitor. Therefore, technology owners applied a strategy in marketing the technology to increase the technology potential and competition (Kim, 2009).

The conditions and type of agreement in technology licensing also plays a crucial role in the competition between companies as it may provide opportunities to enter new markets with potential (Mitchell and Singh, 1992). According to Kim (2009), technology owners consider technology licensing as a risk that may lead to sharing competitive knowledge with others which may increase their strength and capability in developing technologies and becoming a technology leader and developer, and might minimize the competition. Therefore, technology owners always avoid discussing the details of the technology with direct competitors.

### 4.6 Benefit realization and technology investment

In the worldwide business arena, it has been considered that the amount of technology is increasing and, in some cases, technology investment may cost an organization half of its annual capital expenditure (Willcocks and Lester, 1997). Worldwide investment in
technology was expected to increase to over US$3.2 trillion in 2007 (WITSA, 2004). It can be seen from this large amount of money that investment in technology is very considerable, and important for all the business and industrial sectors around the world. For that reason, it is necessary for any organization to realize the benefits of any technology investment, to avoid any waste of budget and opportunities. In the past few years, measuring the possible benefits of an investment has become an explicit and important requirement (Lillrank et al., 2001; Murphy and Simon, 2002). Benefit has been defined by the Office of Government Commerce (OGC, 2007) as

> “the quantifiable and measurable improvement resulting from an outcome which is perceived as positive by a stakeholder and which will normally have a tangible value, expressed in monetary or resource terms. Benefits are expected when a change is conceived. Benefits are realized as a result of activities undertaken to effect the change”.

The meaning of benefit realization is “not to make good forecasts but to make them come true ... and technology on its own does not deliver benefits” (Ward et al., 1996). Bradley (2006) has also defined benefit realization as “the process of organizing and managing, so that potential benefits, arising from investment in change, are actually achieved”. Organizations should start planning for benefits management and realization before an investment or project is accepted and authorized by top management or department managers. A clear identification of required strategic benefits should also be included (OGC, 2008). Ward and Griffiths (1996) reported that pre-investment planning is important, to ensure that the required benefits are realized and achieved by an organization. According to Lederer and Mirani (1995), realizing the benefits of technology investment is very significant for many reasons:

- It can provide researchers with the chance to describe technology projects thematically;
- It can encourage a deeper realization of investment outcomes;
- It can help managers to have a clear direction for exploring new investment in the future.
However, understanding the benefits and outcomes of investment is a major key to success in a decision-making process. In global business, knowing the benefits and returns on investment is one of the priority tasks during planning for the investment. Realising the benefits is described by several researchers as identifying, managing, planning, modelling, and tracking potential benefits (Changchit et al., 1998; Lillrank et al., 2001; Murphy and Simon, 2002; Ward et al., 1996). Determining and realising investment benefits can be done using different methods and techniques. Benefit-realization methods are becoming essential tools in evaluating investment, thus ensuring that the expected benefits are realizable to support implementing the investment decision (Changchit et al., 1998). Benefit realization can be defined as a process that includes planning and identifying how and when benefits should be realized and who is responsible for planning for the full benefits (Ward et al., 1996).

### 4.7 Difficulties and challenges with benefit realization

Recently, difficulties with introducing new technologies have forced business executives to look for new ways of assessing and managing benefit realization. At present, it is widely accepted that the first stage of the benefit realization process should take place during pre-planning of the project (Lock, 2003). Measuring the expected benefit of a particular technology is complex and not easy to do (Remenyi and Whittaker, 1996; Seddon et al., 2002). According to Norris (1996), the inability to produce a clear report for the expected benefits from technology may lead to project failure. Thorp (2001) claimed that difficulty in realizing, and failure to track, the business benefits of technology investments are among the most common problems in benefit realization and management.

According to Lin et al. (2005), few organizations consider how expected benefits should be realized. Even those who use a benefits management approach face various problems and challenges. Wilson (1991) reported that difficulty with measuring benefits might be one of the causes of failure in achieving the targeted strategy. Monitoring the benefits of technology by organizations can be unsuccessful for several reasons, such as:
• It is not easy to measure the benefits of the technology after implementation (Norris, 1996);
• It is not essential to measure the benefits if the project was implemented according to plan (Norris, 1996);
• The high cost of investment can be a deterrent to undertaking proper post-implementation reviews of the benefits (Norris, 1996);
• Many organizations are not aware of the importance of realizing intangible benefits before making an investment decision (Beaumont, 1998);
• Unsuccessful technology adoption practices (Fink, 1998).

Several studies have identified a number of factors that may affect the use of benefit realization methodologies in firms (Lin and Pervan, 2003; Truax, 1997). The majority of these factors are linked with organizations’ awareness of, and readiness to use, these methodologies. Lin and Pervan (2003) reported some problems and challenges that affect the understanding of benefit realization and management, such as top management’s attitude and thinking towards technologies and the difficulties in evaluating and understanding the technical issues related to the technology. The same author suggests that failure to recognize benefits in terms of organizations’ business objectives is one of the challenges. Truax (1997) has identified three causes of unsuccessful benefit realization of technology investment:

1. The nature of the project
2. The limited ability of the organization
3. Poor planning and failure to identify the benefits
4.8 Summary

This chapter presented the literature review of two important issues that play an important role in making investment decisions. Effective investment justification, and management of the benefits of investment and projects, allows decision makers to make the correct strategic decisions which in turn ensure that the strategic aims and objectives are achieved. This chapter has sought to recognize and link the importance of justifying investment, and of having a benefit realization approach to support the investment decision. The importance of investment justification and its approaches, such as economic, analytic and strategic justification methods, have been discussed. Furthermore, the “benefit realization” approach has been reviewed and discussed. Benefit realization techniques and approaches help organizations to identify, realize, control and manage the business benefits of technology investments. This enables top management to justify their investments in technology. Finally, this chapter has emphasized that organizations must integrate a benefit realization strategy into their technology investment decisions, in order to successfully manage, and gain the full benefit from, their investments.

Viewing the literature related to investment justification and benefit realization aimed to give a clear picture about its importance and impact on the investment decision-making process. This was reflected in the design of the research, as the next chapter will describe.
Chapter five

Research Design and Methodology
Chapter five
Research Design and Methodology

5.1 Introduction

In this chapter a discussion will take place on how this research will be conducted to achieve its aims and objectives, beginning with an overview of the selected research design followed by a discussion about the research methodology used. Discussion includes an overview of qualitative and quantitative research methods, and the possible criteria and justification for the selection of an appropriate method. A detailed description of the data collection method will be provided including interview schedule, interview style, interview questions, ethical considerations and selection of the companies, followed by a description of the data analysis method used.

5.2 Research aims and objectives

As has been stated, the research aims to investigate and understand the technology investment decisions within the Saudi petrochemical industry, specifically, the factors and difficulties that could affect the companies’ decision-making process. The research will investigate this issue from different areas to provide an in-depth view of what may affect the success of the investment. The research aims to target five different areas that are critically involved in making technology investment decisions; these are investment justifications, technology selection, company readiness toward investment, alignment between technology and business, and the realization of the investment benefits. The detailed understanding of these areas is the main goal that will contribute to addressing the research problem and questions. The following section describes the selected methods for this research.
5.3 Research method

Research is generally defined as a planned, “systematic search for trustworthy and meaningful knowledge” (Verma and Beard, 1981). In order to establish systematic research, several points must be addressed (Bouma and Atkinson, 1995). These might be summarized as follows:

- Identifying the problem;
- Reviewing the literature;
- Deciding on techniques to be used for collecting and analyzing information;
- Selecting and defining the sample to be studied;
- Collecting the data;
- Processing, analyzing and interpreting the results;
- Writing up the report.

Literature classifies research into two main types: quantitative and qualitative. Quantitative studies involve using questionnaires, social surveys, experiments and attitude-scales. Such methods allow the researcher to conduct a large-scale analysis. Qualitative studies, on the other hand, involve the use of case studies, open-ended interviews, ethnography (participant observation) and triangulation (Yin, 1994).

The qualitative/quantitative debate is not just a matter of appropriate instruments. Bryman (1993) indicates eight dimensions on which these two types of research traditions diverge. Table 5.1 presents the differences between the two types of research.
Denscombe (1998) summarizes the differences between quantitative and qualitative research. Table 5.2 provides a summary of the advantages and disadvantages of the quantitative and qualitative research methods.

<table>
<thead>
<tr>
<th>Method</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantitative</td>
<td>• Provide wide coverage of the range of situations &lt;br&gt; • Fast and economical &lt;br&gt; • Can be of considerable relevance to policy decisions</td>
<td>• Tend to be somehow inflexible and artificial &lt;br&gt; • Not very effective in understanding processes or the significance that people attach to actions &lt;br&gt; • Not very helpful in generating theories &lt;br&gt; • Since they focus on what is or what has been recently, they make it hard for policy makers to infer what changes and actions should take place in the future</td>
</tr>
<tr>
<td>Qualitative</td>
<td>• Data-gathering methods seen more natural than artificial &lt;br&gt; • Ability to look at change processes over time &lt;br&gt; • Ability to understand people’s meanings &lt;br&gt; • Ability to adjust to new issues and ideas as they emerge &lt;br&gt; • Contribution to theory generation</td>
<td>• Data collection can be tedious and require more resources &lt;br&gt; • Analysis and interpretation of data may be more difficult &lt;br&gt; • It is hard to control the pace, progress and end-points of research process &lt;br&gt; • Policy makers may give low credibility to results</td>
</tr>
</tbody>
</table>

Table 5.2: Advantages and disadvantages of quantitative and qualitative research methods  
(Source: Amaratunga et al., 2002)
In general, qualitative research is more appropriate in building theory and explanations, and possibly theory testing in some cases (Sutton and Staw, 1995; Yin, 1994). The main intent of qualitative research is to provide in-depth details or description of a case or action. The nature of the data produced by qualitative research comes in the form of words, not statistics or figures. The evaluation of qualitative data depends on the researcher’s understanding and interpretations. On the other hand, the quantitative approach aims to give more numbers and statistics through experimental design and surveys (Whinston et al., 1997).

The qualitative approach or method is widely used and can be used in many different disciplines. Denzin and Lincoln (1994) described the qualitative method as an “interdisciplinary, trans-disciplinary, and sometimes counter-disciplinary field”. Multiple ways can be used to gather qualitative data, including interviews, documents and observations. Applying multiple methods to the research in a single study can support the researcher in developing a strong position and “richness” to gain more understanding about the research hypothesis and to achieve satisfaction (Johnson and Onwuegbuzie, 2004). In addition to the qualitative approach, quantitative methods are frequently used with particular types of sciences and studies such as maths, physics and chemistry. The debate between qualitative and quantitative research is well summarized by Denzin and Lincoln (1994):

*The word qualitative implies an emphasis on processes and meanings that are not rigorously examined or measured (if measured at all), in terms of quantity, amount, intensity, or frequency. Qualitative researchers stress the socially constructed nature of reality, the intimate relationship between the researcher and what is studied, and the situational constraints that shape inquiry. Such researchers emphasize the value-laden nature of inquiry. They seek answers to questions that stress how social experience is created and given meaning. In contrast, quantitative studies emphasize the causal relationships between variables, not processes. Inquiry is purported to be within a value-free framework.*
For the purpose of this research study, qualitative case study methods are considered to be most appropriate to address the research question and objectives. This allowed a detailed investigation of the various elements of the decision-making process. Bryman (1993) has described the benefit of qualitative research as: “...it expresses commitment to viewing events, actions, norms and values from the perspective of the people being studied”. Therefore, qualitative methods can give a rich perspective on the research objectives from the perspective of the decision methods within the petrochemical industry.

5.4 Research structure and process

To address the research question and objectives, the research followed a sequential process and structure that includes a number of steps and activities. As Figure 5.1 illustrates, the research process started with reviewing the related literature on investment decision-making and ended with drawing final conclusions and recommendations. With regard to data collection, the research conducted two different studies adopting qualitative research methods. The first study used semi-structured interviews aiming to investigate and explore the Saudi petrochemical companies’ investment decision-making process and the possible difficulties and factors affecting the industry. This involved interviews with senior managers within four Saudi petrochemical companies.

In addition, the first study focused on investigating the decision-making issues at a company level which helped to highlight the critical factors that the petrochemical companies face. However, the analysis of the first study findings needed to be supported by an in-depth investigation which resulted in a second study using semi-structured interviews. To gain better understanding and valuable data, the second study focused on investigating the decision-making process based on a project level which helped to understand the specific issues and factors affecting companies’ investments decisions.
5.5 The case study research method

The case study is well known and widely used in qualitative research. The case study method can be used alone or with other methods and techniques. Schramm (1971), as cited by Yin (2003), describes case study research as
an empirical inquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident... [It also] copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result relies on multiple courses of evidence, with data needing to converge in a triangulating fashion, and as another result benefits from the prior development of theoretical proposition to guide data collection and analysis.

In addition, and to be more specific, Yin (2003) proposes the following, more complete definition for case study research:

1) A case study is an empirical inquiry that:

   • Investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident.

2) The case study inquiry:

   • Copes with the technically distinctive situation in which there will be many more variables of interest than data points, and as one result.
   • Relies on multiple sources of evidence, with data needing to converge in a triangulating fashion, and as another result.
   • Benefits from the prior development of theoretical propositions to guide data collection and analysis.

As the research objective is to investigate the technology investment decision-making process and its related factors and difficulties, four petrochemical companies were selected as case studies for this research. Two studies were conducted, and each study adopted a different strategy. The first study focused on looking at the investment decision-making process based on the company level and overall process. This was
conducted by interviewing business executives who are involved in making final decisions, which allowed them to express their views regarding the companies’ decision process. As a result of the first study, many issues and factors were identified that required an in-depth investigation for better understanding of the problems. A second study was conducted adopting a strategy based on investigating the investment decision-making on a project level. This focused on looking at the decision-making process of successful and unsuccessful projects that each company experienced to gain more specific and detailed data about the factors and difficulties that affected the petrochemical companies’ investment decision process.

5.6 Criteria for the selection of the case study

The selection of the petrochemical companies for the case study was based on several factors related to the sector, company size, projects, investments, locations, products and experience. It was believed that such factors may affect the investment decision-making process. The investigation of the decision-making processes within the companies took into account recent and previous investment projects, the technologies used and company policy. Furthermore, it is very important to gain better understanding of the decision making-processes used to obtain a clear picture about the situation and when decisions were taken (Mason and Rogers, 1997).

With regard to the selection of the companies, initially eight petrochemical companies within Saudi Arabia were contacted by phone and email. A positive response was received from four companies who agreed to participate in the research. Eisenhardt (1989) claimed that “while there is no ideal number of cases to include in a sample, a number between 4 and 10 usually works well”. The selected sample for this research study was based on a purposive sampling which allows the author to select respondents involved in decision making, or decision makers who have full awareness of decision-making processes used within the company (Sarantakos, 1998).
5.7 Data collection methods and research style

A qualitative research methodology was selected as the most suitable method to investigate and examine the investment decision-making process. The qualitative research method can provide the researcher with a good understanding and explanation of the applied decision process (Mason and Rogers, 1997). Semi-structured interviews are a suitable method to encourage research participants to provide detailed and flexible data (Gubrium and Holstein, 2002; Kvale, 1996). The research interviews adopted a style that was designed to encourage free-flowing narratives; this style is widely used with research related to investment decision-making (Jarvis et al., 1996). The aim of making use of this style is to give the interviewee space to speak freely and without restraint on their answers to the questions asked. Thus, a rich discussion can take place by giving the respondents the opportunity to use their own words to describe their experience (Spence and Rutherford, 2001).

“Elite” interviewing is a widely used technique in the political sciences, especially with “elite” decision makers or people who are responsible for particular information and data (Burnham et al., 2004). Elite interviewing is considered to be appropriate when the respondent is an expert or in a position to inform about the subject being investigated (Kezar, 2003).

Elite interviewing techniques were applied in the first study which involved four interviews with chairpersons and CEOs of Saudi petrochemical companies, to explore the executives’ and final decision makers’ thinking toward the factors and difficulties that they faced in their investments. For the second study, interviews were held with people involved in the planning and analysis of investment decisions such as project managers, business developers, marketing managers, and finance and operation managers. The aim of this strategy is to investigate in depth the factors and difficulties that they experienced during the decision-making stages. A total of 14 interviews were conducted for the first and second studies with different representatives in different positions within the four companies. Table 5.3 shows the profiles of the respondents.
Table 5.3: The interviewed respondents in the four companies for both studies

<table>
<thead>
<tr>
<th>Company A Representatives</th>
<th>Company B Representatives</th>
<th>Company C Representatives</th>
<th>Company D Representatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vice-Chairman and CEO</td>
<td>Executive Vice-President, Corporate Finance</td>
<td>Founder, Chairman and CEO</td>
<td>CEO</td>
</tr>
<tr>
<td>Marketing Executive</td>
<td>Senior project manager</td>
<td>SVP Finance</td>
<td>Senior project manager</td>
</tr>
<tr>
<td>Business developer</td>
<td>Senior project manager</td>
<td>Business developer</td>
<td>Marketing manager</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Operation and projects manager</td>
</tr>
</tbody>
</table>

5.8 Interview questions and guide

To address the research questions and objectives, interview guides have been designed for the first and second studies. This section describes the interview guides, taking into account the research objectives.

5.8.1 The first study

In the first research study, a qualitative case study approach was applied, including semi-structured interviews. The research focused on exploring the investment decision-making process within the petrochemical companies. The first study aimed to address the first two objectives which are, firstly, to examine the extent to which the decision-making activities, criteria and methods implemented by petrochemical companies are related to the efficacy of the decision-making process; and secondly, to identify the important internal and external factors that influence technology investment decision-making and evaluation practices in petrochemical companies. Table 5.4 shows the targeted areas linked with the research objectives. Appendix one includes a copy of the applied guide and questions.
The first study was conducted in the period August 2009 – November 2009; this includes the design of the questionnaire, contacting respondents and data collection. Interviews were arranged by email and phone. All the interviews were conducted face to face with the respondents at their offices in Saudi Arabia and interviews were recorded after asking the respondents permission.

<table>
<thead>
<tr>
<th>Areas</th>
<th>Issues</th>
<th>Research objectives</th>
</tr>
</thead>
</table>
| The implemented decision-making process | • The availability of a documented decision  
• The applied decision-making process | Objective one: To identify the internal and external factors that influence technology investment decision-making and evaluation practices in petrochemical companies. |
| Factors influencing the investment decisions | • Organizational factors  
• Operational factors  
• Internal factors  
• External factors | Objective one: To identify the internal and external factors that influence technology investment decision-making and evaluation practices in petrochemical companies. |
| Challenges and difficulties       | • Difficulties that influence the decision-making process               | Objective one: To identify the internal and external factors that influence technology investment decision-making and evaluation practices in petrochemical companies. |

Table 5.4: The examined research aspects and issues for the first study linked with research objectives

CEOs and company chairpersons involved in making the final investment decision in four companies were selected as respondents for the first study.

5.8.2 The second study

To fully address the research objectives, a second study was applied to gain more in-depth information about the technology investment decisions within the petrochemical
companies. The second study aimed to address the remainder of the objectives: investment justifications, technology selections, company readiness, alignment and benefit realization. The study aimed to investigate in detail the decision-making factors and difficulties and their impact on the direction of the decision-making process. The guides and questions are included in Appendix two. Table 5.5 is a guide to the second study.

<table>
<thead>
<tr>
<th>Investigated areas</th>
<th>Key issues</th>
<th>Link with the research objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Investment justifications</strong></td>
<td>• The justification process&lt;br&gt;• Factors and difficulties&lt;br&gt;• The impact on the investment decision process</td>
<td>Objective three</td>
</tr>
<tr>
<td><strong>Technology selection</strong></td>
<td>• The technology selection criteria and process&lt;br&gt;• Factors and difficulties&lt;br&gt;• The impact on the investment decision process</td>
<td>Objective four</td>
</tr>
<tr>
<td><strong>Company readiness and alignment</strong></td>
<td>• The company abilities and alignment actions&lt;br&gt;• Factors and difficulties&lt;br&gt;• The impact on the investment decision process</td>
<td>Objectives five and six</td>
</tr>
<tr>
<td><strong>Benefit realization</strong></td>
<td>• The benefit realization process&lt;br&gt;• Factors and difficulties&lt;br&gt;• The impact on the investment decision process</td>
<td>Objective seven</td>
</tr>
</tbody>
</table>

Table 5.5: The examined research aspects and issues for the second study linked with research objectives

For the second study, interviews were conducted at a less senior management level than the first study. The second study aimed to gather in-depth information by interviewing people who are involved in planning for the decision-making process, such as project managers, business developers, marketing managers, finance and operation managers. Arranging the interviews was supported and authorized by the interviewed CEOs in the
first study. In the second study, two people from each company were interviewed to investigate the factors and difficulties that affect the investment decision-making process.

The second study was conducted in the period October 2010 – January 2011; this includes the design of the questionnaire, contacting respondents and data collection. The interviews were conducted by targeting and contacting respondents who are involved in planning for making investment decisions. Interviews were arranged through email and phone conversations. The second study interviews were conducted by telephone. All were recorded after asking the respondents permission.

5.9 Data analysis methods

The analysis of the data for both research studies was conducted through a number of steps and techniques, applying the method outlined in Yin (2003). After producing the transcriptions from each interview, the analysis was started by categorizing, highlighting, linking and coding all the respondents’ answers. This was followed by an individual analysis of each company, then a cross-case study which reflected the differences and similarities between companies’ decision-making processes and the related factors. Cross-case analysis (Eisenhardt, 1989; Yin, 2003) was used to support the researcher in building possible explanations from the findings.

This section presents the data analysis methods used for this research study. The analysis of the collected data adopted a three-step process for analyzing qualitative data designed and recommended by Yin (2003); the three steps are data management, analysis of individual cases and cross-case analysis (Figure 5.2).
5.9.1 Data management

After conducting interviews with the selected respondents, data management began by producing transcriptions of all the recorded interviews for the first and second studies. Producing transcriptions helped the researcher to organize the data to facilitate individual and cross-case analysis. The data from field notes and transcribed recordings were organized and prepared in a Microsoft word file. In addition, all the recorded interviews were saved on the computer as audio files, followed by producing written transcripts. The transcripts were organized by highlighting, identifying, coding and categorizing all the major themes or ideas for each company separately. The aim of this step is to reduce the amount of data and to produce better, manageable and useful data as a source of evidence. Table 5.6 is an example of a simple matrix showing how the respondents’ answers were summarized and compared for each company in both studies. Applying this technique helped to organize the collected data for conducting the cross-case analysis and understanding the facts from each case.
<table>
<thead>
<tr>
<th>Questions</th>
<th>Company A respondent 1</th>
<th>Company A respondent 2</th>
<th>Company B respondent 1</th>
<th>Company B respondent 2</th>
<th>Company C respondent 1</th>
<th>Company C respondent 2</th>
<th>Company D respondent 1</th>
<th>Company D respondent 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.12 What process was used to identify the expected benefit from this investment? Please explain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.1 Please explain what are the applied techniques for investment justification for this project?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.3 What factors affected negatively the investment justifications?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.2 What factors affected the ability to select the most appropriate technology? Please explain</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5.6: Example of a simple matrix of how the respondents’ answers were compared in the first and second research study
5.9.2 Analysis of the first study

The individual analyses of the interviews for each case started by describing each company background and identifying the applied decision-making process in each company. This was followed by identifying each company’s investment decision-making process. In addition, an identification of the main factors and difficulties was discussed and categorized into the five elements of the decision process; these are, investment justification, technology selection, company readiness, alignment, and benefit realization. The first study aimed to explore and identify the weaknesses and strengths in each company by identifying how each company approaches their investment decision-making process.

The analysis of the first study was conducted by applying an individual analysis of each company, identifying the issues, factors and difficulties. This was followed by a cross-case analysis of the four companies’ findings by identifying the similarities and differences which helped to identify the possible gaps in the companies’ decision-making processes. According to Boonstra (2003), the aim of conducting a cross-case analysis is to find and compare the variations, and to recognize links and patterns between the cases to classify them into certain groups. Therefore, the analysis of these gaps was the main support for the design of the questionnaire for the second study, by highlighting the critical issues that need to be investigated in the second study.

5.9.3 Analysis of data from second study

For the second study, the case study focused on targeting the decision-making process based on a project level to gain in-depth information about planning for the decision-making process. Targeting projects within the four companies, we focused on investigating successful and unsuccessful investments that the petrochemical companies had experienced. Successful projects were based on the level of satisfaction of the return and benefits, and unsuccessful projects reflected those rejected or not completed, or that
did not achieve the targeted benefits or business objectives. The analysis of the findings for each company was conducted, firstly, through individual analysis of each project within each company, and then followed by a cross-case analysis.

The cross-case analysis for the second study was conducted by comparing the variations between the four companies’ successful and unsuccessful technology investment. Investigating experienced successful investments aimed at identifying the contributors and the key success factors that helped to achieve the company’s business objectives. The second study investigated unsuccessful investments experienced and the critical issues faced, and how they influenced the decision-making process. This helped to identify the common patterns, factors and difficulties categorized into five different elements according to the issues emphasized in Table 5.5. Cross-case analysis can be carried out using analyzing techniques such as “pattern matching”, “analytic generalization” or “explanation-building”, as suggested by Yin (2003). The findings from these methods are expected to be stronger than the findings from an individual case (Yin, 2003). Therefore, the research made use of three methods:

- **Content analysis**: this involved reviewing and rereading the interview transcripts and notes of each case. The content analysis helped to categorize the data into the five elements of the decision-making process.

- **Pattern-matching**: as a result of the content analysis categorization, the pattern-matching technique was used to identify whether any interesting patterns can be recognized, such as the differences and similarities between cases; also whether anything stands out as unexpected or unknown.

In the second study, pattern-matching was used to identify the differences and similarities between the companies to compare the findings. For example, pattern-matching was applied to four cases to find the links that caused difficulties and factors in the companies’ decision-making processes. This helped to identify shared factors and difficulties between the companies, which is considered as a
base for finding explanations that may affect the decision-making process. Pattern-matching for this study was conducted using the organized and coded data, which allowed effective comparison of data.

- **Explanation-building:** This method is used with pattern-matching, and is most commonly used in explanatory cases. According to Yin (1994), explanation-building techniques aim to analyze the case study data by building an explanation about the case by identifying and placing causal links. This will help to link the explanations found with the related theory.

For the four case studies, the explanation-building technique helped to understand and clarify the companies’ investment decision processes and the causes of the difficulties and factors, which helped to identify the impact of the facts on the investment decision process and the five elements. Explanation-building was based on categorized differences and similarities between the cases.

The outcomes of cross-case analysis show the possible patterns, relationships, and concepts of the research. Also, the outcomes and findings can be utilized for comparison and validation. Eisenhardt (1989) suggests an approach for cross-case analysis that includes three useful methods. These methods can help to set and design categories or dimensions for the collected data, the pairing and comparing of cases, and the division of data by data source.

- **Selecting categories or dimensions:** aim to explore and classify the possible within-group similarities and between-group differences.

- **Selecting pairs of cases:** this will help the researcher to investigate and identify the possible similarities and differences that might be overlooked, by creating lists of similarities and differences across the cases.
• **Dividing the data by data source:** This technique was applied in the separation of the analyses of qualitative and quantitative data in the research on strategic decision-making (Bourgeois and Eisenhardt, 1988; Eisenhardt & Bourgeois, 1988). The technique can bring the benefits of analyzing the findings from each data source and then attempt to triangulate the findings from different sources. It can also help to identify the conflicts and patterns between cases (Eisenhardt, 1989).

This technique was applied to this research study to support presenting the data within the five elements of the decision-making process. The data within the five elements were then divided into three sections to support presenting the issues found in accordance with the interview guide. The next section describes the data display method.

**5.9.4 Data display**

In this study, the display of the findings and the analysis of the second study cross-case analysis were based on the design and aims of the interview questions. The questions aimed to investigate three areas in each element: 1) the process used; 2) the factors and difficulties encountered; and 3) the impact on the decision progress. Table 5.7 shows the categorization and the links between the questions and the heading of each element.
### Questions

<table>
<thead>
<tr>
<th>Questions</th>
<th>Investment benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 In what stages did your company identify the expected benefits from this investment? Please explain</td>
<td>The process used</td>
</tr>
<tr>
<td>2.2 What process was used to identify the expected benefits from this investment? Please explain</td>
<td>Factors and difficulties encountered</td>
</tr>
<tr>
<td>2.3 What difficulties had your company faced with the applied process?</td>
<td></td>
</tr>
<tr>
<td>2.4 Please identify what factors contributed to identifying the expected benefits?</td>
<td></td>
</tr>
<tr>
<td>2.5 What are the realized benefits? And did you realize all the benefits? If not, why?</td>
<td></td>
</tr>
<tr>
<td>2.6 If the realized benefits were less than what your company was expecting, why did this occur?</td>
<td></td>
</tr>
<tr>
<td>2.7 If the realized benefits were less than what your company was expecting, what actions did your company take as a result?</td>
<td>The impact on the decision progress</td>
</tr>
<tr>
<td>2.8 If the realized benefits were less than what your company was expecting, how did this affect how you made the subsequent investment decisions?</td>
<td></td>
</tr>
<tr>
<td>2.9 If the realized benefits were less than what your company was expecting, how did this affect how you made the subsequent investment decisions?</td>
<td></td>
</tr>
</tbody>
</table>

**Table 5.7: Example for the categorization of the analyzed data for investment benefits**

### 5.10 Summary

As the aim of the research study is to examine the investment decision-making process within petrochemical companies, a qualitative methodology was selected as the most appropriate, based on the nature of the data and the type of respondents. The researcher selected four different companies for the case study to provide data applicable to understanding the research problem; all the targeted companies were from the petrochemical manufacturing sector in Saudi Arabia. However, the interviews were semi-
structured to provide more flexibility as well as provide an opportunity for respondents to raise important issues during the interviews. The interview style adopted was considered to encourage free-flowing narratives for the investigation on investment decision-making. The aim of using this style was to allow the respondents to speak freely, without restricting their comments during the questioning process. All the initial interviews lasted for about two hours each and were recorded on a voice digital recorder.

Data analysis for this study made use of a number of analysis techniques such as content analysis, pattern matching, and the explanation-building technique. The process of analyzing the data collected began with data management, followed by individual analysis of the four cases, and finished with a cross-case analysis. However, as a result of using this method, the next section will discuss and present the results and analysis of the findings.
Chapter Six

Elite decision maker study
Chapter Six

Elite decision-maker study

6.1 Introduction

The aim of this chapter is to present the analysis and results from the first stage of this research. The first study was considered as an initial step for this research to explore the investment decision-making process within petrochemical companies. It was also important in providing a clearer understanding of the factors and difficulties that could affect the investment decisions within the petrochemical industry. As the previous chapter discussed, the first study adopted a qualitative research approach to provide an in-depth view of the applied investment process and its related factors. Semi-structured interviews were used with elicit free-flowing narrative style to encourage research participants to provide detailed and flexible data. This stage involved the “Elite” interviewing technique, as the targeted respondents are top-level decision makers within the four selected companies.

6.2 The design of the first study and interviews

To address the research question and objectives, the design and planning of the interviews for the first study was critical. The time required for each interview was also considered a critical issue because of the difficulties in obtaining the required time from CEOs and decision makers within petrochemical companies. The duration of the interviews was planned at between one and a half and two hours. The interview was designed to ask specific questions that could provide background on the decision-making
process. The questions for the interview (See Appendix one) consist of two different sections; the first section aimed to gain biographical data, the qualifications of the respondents, company information, investments, activities, productions and technologies used. The second section focused more on asking questions about the applied decision-making process within the company and the factors and difficulties that affected the company technology investments.

Although it was difficult to arrange interviews with decision makers and CEOs within petrochemical companies because of the limited number of companies and the busy schedules of the targeted people, the research managed to meet six people who are involved in making investment decisions within four Saudi petrochemical companies. Each case study company was analyzed under the following three sections:

- The applied investment decision-making process within the companies;
- Key elements that impact the investment decision-making process. These are reviewed under the following headings:
  
  a) Investment justifications
  b) Technology selection
  c) Company readiness
  d) Technology and strategic alignment
  e) Investment benefit realization and management.
6.3 Result and discussion

6.3.1 Company background and description

The first study targeted four major petrochemical companies in Saudi Arabia. Each of the companies is different in terms of size, investments, projects, strategies and financial performance. This section will aim to provide a brief description of each company’s background and activities.

Company A

Company A was established in the mid-nineties, and was then considered to be one of the first joint-stock petrochemical company in Saudi Arabia fully owned by the private sector. The company went down the route of industrialization as one of the most appropriate ways of diversifying the economic base and boosting overall expansion and development in the country. Most of Company A’s activities are investments within the petrochemical and chemical industry sector. This includes technology to be used in manufacturing and processing petrochemicals and chemicals, engineering and mechanical industries, the management and acquisition of industrial projects and marketing their products. Company A specialized in the field of manufacturing and marketing petrochemical products such as ethylene, polyethylene, propylene and polypropylene. (Tadawul, 2009).

Company B

Company B was established in mid-seventies to produce basic petrochemical products such as polymers and fertilizers. The company is considered to be one of the largest and most profitable petrochemical companies in the region. Company B is engaged in the manufacturing, marketing and distribution of petrochemicals, plastics, fertilizers, metals, and basic hydrocarbon products. Company B is a joint venture between the Saudi government and the private sector. (Tadawul, 2009).
**Company C**

Company C is an international titanium dioxide producer, established in the late eighties. Company C is considered as one of the largest titanium dioxide producer globally. The company is also considered the largest producer of merchant titanium chemicals, and the leading manufacturer of field titanium products. The company provides many products and services for a range of industries around the world, from coatings to paper and polymers to pigments (Zawaya, 2009).

**Company D**

Company D was established in the early nineties to take advantage of Saudi Arabia's natural hydrocarbon and mineral resources. The company is a Saudi joint stock company. The company develops worldwide, cost-competitive industrial projects based on provided feedstocks in strategic partnership with the world’s major petrochemical companies. Company D’s main production activities include manufacturing petrochemical products such as ethylene, polyethylene, propylene and polypropylene (Tadawul, 2009).

**6.3.2 The investment decision-making process**

Company A considers making investment decisions as a very important process, requiring a great deal of attention and care. According to the respondent, Company A does not have a documented decision-making process, claiming that in-house wide experience helped and supported it in dealing with all the possible investment decisions without the need for a guide or process. However, this does not mean that the company did not face any difficulties or challenges during the decision-making processes for new investments. The chairman stated that, in some cases, the company needed to utilize the services of professional consultants to deal with some of the challenges and to improve their investment decisions.
Company A generally begins the decision-making process by looking for investment opportunities, allocating a group of professional people to look at possible investment opportunities. The searches are based on different criteria, which are in line with the company’s strategy and goals, such as the type of technology, availability of technologies, the cost of the project and its requirements. These criteria are all very important to consider before going to the next step, which is for the team to produce a list of attractive projects for the company’s top management and committees.

With more than one attractive potential project, the company reviews all the possible opportunities before giving the go ahead to start feasibility studies for the selected investments. Within these feasibility studies, the company focuses on assessing the availability of the necessary resources for the selected investment, such as natural resources, budget and skills, which are vital to secure before going any further.

The evaluation of the feasibility study and the potential to secure the necessary resources allows the company to decide whether to finalize the feasibility study or not. According to the respondent, the full feasibility study will give the company a clear picture about the ability to implement the proposed investment. Depending on the company’s capabilities, the CEO will make an initial decision on the proposed investment before it goes to the company board to get final approval. Figure 6.1 shows the company investment decision steps, as analyzed from the research interview.
Unlike Company A, Company B applies a unique decision-making process designed by the company itself called the “Gate Process”. The Gate Process is a systematic, formalized step-by-step approach to developing and executing a project and covers all the project phases, from the first step in the decision-making process through to completion. The Gate Process has six principles (Company B documented decision-making process), which are:

- Consistent and structured approach for development and execution of all capital investment;
- Project evolution to be divided up into well-defined phases;
• A phase is a collection of logically related activities culminating in major deliverables;
• The progression of moving from phase to phase is managed by a Gate Keeper employing the project’s Gate Process;
• Funds and resources are spent progressively and only as necessary while moving from one phase to the next;
• Responsibilities, accountabilities and requirements are to be clearly defined for the entire process and for each phase.
Company B’s investment decision-making process consists of seven different phases (see Figure 6.2), with each phase dependent on the one before. To make an initial investment decision, the project sponsor must go through phases one and two, which are Concept rationalization and pre-feasibility, and Feasibility and venture philosophy. Conducting
phases one and two should help the company to measure several important factors by inputting related data to produce important outputs to support the decision and progress to the next phase. Table (6.1) shows the inputs and outputs of phases one and two.

<table>
<thead>
<tr>
<th>Phase one inputs</th>
<th>Phase one outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Strategic business fit</td>
<td>Assign sponsor</td>
</tr>
<tr>
<td>1.2 Synergy with existing operations</td>
<td>Plan for next phase</td>
</tr>
<tr>
<td>1.3 Site availability review</td>
<td>Budget for next phase</td>
</tr>
<tr>
<td>1.4 Raw materials and utilities availability review</td>
<td>Assign E&amp;PM coordinator</td>
</tr>
<tr>
<td>1.5 Technology requirements</td>
<td>Checklist for strategic planning</td>
</tr>
<tr>
<td>1.6 Options study</td>
<td></td>
</tr>
<tr>
<td>1.7 Pre-feasibility study</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Phase two inputs</th>
<th>Phase two outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Technology assessment</td>
<td>Feasibility checked</td>
</tr>
<tr>
<td>2.2 Preliminary feasibility study</td>
<td>Venture philosophy endorsed</td>
</tr>
<tr>
<td>2.3 Preliminary project economics</td>
<td>Guidelines developed for:</td>
</tr>
<tr>
<td></td>
<td>• Project scope</td>
</tr>
<tr>
<td></td>
<td>• Execution plan</td>
</tr>
<tr>
<td>2.4 Marketing study</td>
<td>Checklist for strategic planning</td>
</tr>
<tr>
<td>2.5 Project risk analysis</td>
<td></td>
</tr>
<tr>
<td>2.6 Safety and environmental impact study</td>
<td></td>
</tr>
<tr>
<td>2.7 Class 1 cost estimate (± 40%)</td>
<td></td>
</tr>
</tbody>
</table>

Table 6.1: Stages one and two of company B’s decision-making process
In Company C, the planning and analysis process for new technology investments is a traditional decision-making process and similar to any other decision-making process. The company does not have a documented or specific decision-making process to follow with regard to new investment. However, the company follows a general straightforward and simple process that engages all the company’s departments in working on the planning and analysis for the new investment. In most cases, the company’s investments are based on acquisitions of other competitive companies with similar activities and operations. According to the respondent, the reason for considering acquisitions in order to make new investments is to avoid the possible risks of, and time involved in, starting a new project from scratch. On the other hand, the objective of the company’s acquisitions is to buy and invest in chemical plants in different locations in order to increase the company’s value.

Before considering available investment opportunities, Company C measures its financial potential and its ability to make new investments, knowing the current financial situation is the key to determining the size of investment needed and other important factors, such as the location and type of technology. After measuring its financial potential, Company C starts scanning and searching for the most appropriate opportunities, which are then considered before the selection stage. When searching for opportunities for investment, a number of important factors such as cost, location, technology and added value are considered. Taking into account all of these factors, the company starts the selection process by conducting an in-depth study before presenting the outcomes to the company president.

Selection of the most appropriate investment opportunity is followed by a feasibility study, which identifies all the related aspects of the investment and its requirements and expected benefits. The feasibility study report is the final step in the evaluation of the investment opportunity before the executive committee is informed. The feasibility study must be accepted by the company CEO before informing the board members, which is the final process before making the investment decision. Figure 6.3 shows Company C’s investment decision steps as analyzed from the research interview.
Since 1996, Company D’s top management and CEO positions have been changed four times, and this has affected the way important decisions are made and the company’s attitude towards investment. The current top management within Company D is considered to be the most successful in the company’s history, based on the company’s performance in the last six years, which has moved from loss into profit. The success was as a result of top management’s professional ways of managing the company in order to be one of the top petrochemical companies in Saudi Arabia. This success was also

---

**Figure 6.3: Company C investment decision process**
dependent on the decision-making process that the company implemented for making new investments, changes and expansion on projects. The company does not have a documented decision-making process which, according to the company CEO, is not a major issue because the top management’s experience and communication skills are the keys to their investment decision success.

However, the company does follow a process when making any investment decision such as new technology investment. The company starts planning for new investments by searching for investment opportunities based on financial capability and within the local market in Saudi Arabia. The company employs qualified professional employees to search for investment opportunities, and the outcomes of these searches are presented as a shortlist of potential opportunities with brief details. This is then followed up by conducting a preliminary study for all the available opportunities, which focuses on producing a brief assessment of several important factors such as demand, technology, requirements, risks, the availability of needed feedstock and resources. The company’s top management then discusses the outcomes from the preliminary study report to produce an initial selection of the most appropriate investment opportunities. The initial management decision will be followed by in-depth feasibility studies of the selected opportunities before the company board members are informed about the investment details and the expected added value, which is the last step before taking the final decision. Figure 6.4 shows Company D’s investment decision steps as analyzed from the research interview.
6.3.3 Key elements that impact the investment decision-making process

The previous section gave an overview of the four company decision-making processes. Here, the emphasis is to further explore the important issues relating to the research and the decision criteria and activities. The focus of the discussion in this section will be the decision-making process for technology investments.
6.3.3.1 Investment justifications

Within the four companies, justifying the investments is based on different strategies, approaches, and techniques that reflect the companies’ interest in understanding the justification of the investment. For Company A, producing investment justification for petrochemicals manufacturing investment is not a key task in any of the decision-making stages for new investment because the company does not have a formal, documented decision-making process. However, the company does produce some investment justification during the feasibility study, with the focus being on the economic and financial issues, with less attention being given to strategic and operational justification. The research respondents claim that the company relies more on economic and financial justifications to create a positive interest to invest. However, in some previous projects, the economic and financial justifications alone were not enough to justify investment in petrochemical manufacturing technologies:

*The bottom line is the economic and financial aspects of the investment and you cannot justify the project without a clear economical and financial strategy. Identifying the project’s financial justification is the most important for the company.*

CEO, Company A

As has been mentioned before, the company indirectly produced some investment justification during the initial feasibility studies; however, the difficulty in securing enough information about new opportunities and investment for the feasibility study affected the quality of the report, which then had a negative impact on the investment decision. As a result, the company made some rejections and incomplete investment decisions because of the lack of information to influence the decision direction. The shortage of information also affected the company’s investment decision process due to difficulties in measuring and forecasting the future variability of several factors that could have an effect on the decision process, such as the market, competition, oil price, new technologies and global economic trends.
To justify an investment opportunity, Company A first takes into account the investment’s total cost estimates as a priority because of the impact this has on the company’s financial situation and economy. For example, the cost of the necessary resources such as chemical resources, feedstock, utilities, securing a location and infrastructure, is a critical issue for the company and one that has a huge impact on the investment decision. These issues are also considered within the operational and strategic justification, but the company gives priority to financially related issues, which can have an impact on its readiness during the preparation and implementation stages of the investment.

To justify the investment we look at the estimation of the overall project cost first, which will help to identify the budget, resources and abilities for the project.

CEO, Company A

During new investment planning, Company A is in contact with several information sources, such as contractors, consultants and other chemical companies, the aim of which is to support the feasibility study. Although the company gathers information to support the decision, the company uses traditional investment justification techniques to make use of this information in order to make a better decision. This is because the company relies on its own experience as a strong decision-making tool in any step or investment.

To justify the investment we consider different parties as sources of information, such as contractors, consultants, and chemical companies. This will help to support the planning for the infrastructure of the project, which is a very important issue for the justification.

CEO, Company A

Company A considers the financial justifications as priority more than the non-economic justifications in the feasibility studies. The non-economic justification is considered to be difficult as it is more related to the performance of the technology and its possible intangible benefits and added value. The difficulty is not related to the level of
technology or the type of project, but to possible complexities of the technology and project implementation. Therefore, the company takes into account assessing the strengths and weaknesses, and develops a strategy to make better progress in investment decisions.

Taking into account the nature of Company B’s activities, the company’s main investments are in chemical and petrochemical plants and, in the majority of the company’s investments, the technology comes with the new plants. Therefore, the company considers it critical that its investments are justified but manageable. Justifying new investments in Company B is a key task, which can be done during phase one, as described above. The main aim of phase one is to conduct a pre-feasibility study to justify the investment by measuring how the new investment idea fits the company’s strategic business, which in this research is called the strategic justification. Furthermore, phase one aims to produce more important justifications, such as operational justification, which can be done by measuring the existing operations within the company plants. During phase one, the company also checks a number of factors that may support the operational justification before going on to the next phase, factors such as site availability, general raw materials and utilities, looking at the possible technology requirements and options study.

Within phase one, Company B does not consider the financial justifications because of the lack of clarity on the financial information and estimation of the justified investment idea. In phase two, which is called Feasibility and venture philosophy, the company focuses more on market factors, taking into account the financial issues, which can be done by conducting a market study to identify the possible difficulties and challenges that the company would face when marketing the project. After identifying the expected marketing issues, the company produces a cost estimation of the project (± 40%), taking into account the expected financial benefit to justify the investment financially, before moving to the next phase. According to the respondent, estimating and controlling the investment cost in the initial stage of the decision-making process is the main driver for new investments and it can have a positive or negative impact on the investment decision.
The estimated cost and the possibility to control the cost of the investment is the most important factor that will give us a positive intention to support the justification of the investment and the decision progress.

Executive Finance Vice-President, Company B

Company B faces some difficulties that may affect the outcomes of each phase of the investment decision process; these difficulties relate to the understanding of the investment idea. The respondent claimed that the level of understanding of the investment-related aspects is a critical issue. This is considered a great issue, which may delay the progress of the next phases. The respondent also claimed that the delay in producing the required outputs from phase one may result in a lost opportunity, which can be the cost of ignoring the investment idea.

Producing an investment justification within Company C is more focused on the financial side, with less attention given to the strategic and operational justification. However, the company follows a clear strategy before selecting any potential investment opportunity, by measuring its own financial potential and its ability to make any changes or moves. The aim of this is to understand the current state and to make better use of the company’s financial resources, which will help to produce a strong financial justification. Based on its financial ability, the company begins by identifying several important issues to produce strong and sufficient justification before searching for, and selecting, the most suitable investment opportunities to fit the company’s business activities and strategic objectives. These issues include the reason for the investment, the necessary added value, the type of investment required and the suggested location.

We have a number of criteria to justify our investments. The first criterion is the site or the location of the investment and, at the same time, it should be something that we can apply. The second criterion is the technology and the added value of the investment, for example the added value could be the technology or more flexibility on the production expanding.

CEO, Company C
In most of the company investment cases, company C justifies its investment based on its acquisition strategy and criteria. According to the respondents, the acquisition strategy is more related to the strategic justification of the investment. The company implements its acquisitions strategy by buying and investing in chemical plants in different global locations to increase its company value and market share. The company believes that acquisitions are the best way to achieve successful investment and to avoid all the investment risks. The idea of bringing acquisition solutions to the table was raised in 2004 when the company was planning to expand its operations by buying and investing in new technologies. Due to difficulties in getting the license for the targeted technology and its requirements, the company considered the acquisition of similar technologies and business activities in Europe and South America. The company considered these two acquisition opportunities because it recognized that the justifications for them were very strong and they would be valuable financially, strategically and operationally.

Justification for any investment within Company C usually comes in a pre-feasibility study report of all the suggested investment opportunities. The aim of producing a pre-feasibility study report is to look at the initial details of the potential investments and their fundamental requirements. Based on the justifications of each investment opportunity, the company CEO will make an initial selection of the most interesting opportunity in order to start the in-depth feasibility study. So, the justification of the pre-feasibility study report is that it is considered to be the key to the investment decision. On the other hand, the review and the progress of the pre-feasibility report is complex because of the difficulties of convincing the company board about the proposed investment, which may delay the investment decision and result in lost opportunities.

One of the biggest issues is that if the company board members are not knowledgeable about the target acquisitions, it will make convincing them about the investment justification difficult.

CEO, Company C
In Company D, according to the respondent, justifying their petrochemical investments is based heavily on the availability of the feedstock. Local availability is the key to ensuring a successful investment. Identifying the available feedstock will give the company a clear idea about the possible options and opportunities to make the best utilization of these resources:

*The availability of the feedstocks from local suppliers and the utilization plans for the resources are the most important factors for the decision process.*

*We invest locally because of government support and because our understanding of the global economy is limited, which is a barrier to international investment.*

CEO, Company D

Company D’s investment trend is to find the most suitable opportunities within the local market in Saudi Arabia by looking at the niche market and other manufacturing industry needs. This is supported by the features provided by the Saudi government, which gives the company a strong justification to invest locally and, at the same time, avoid global risks. The government support, plus the availability of the feedstock, are the two main elements that drive the investment, which gives the company management a signal to start searching for a project idea to utilize these resources. The respondents claimed that poor planning and the failure to exploit the feedstock and the government support are the main factors that could affect the decision-making process, leading to an overall failure.

The previous sections have covered the different aspects, processes and factors of investment justifications within the four companies by detailing and analyzing respondents’ views on them. The next section covers the technology selection processes and the considered factors identified by the respondents, based on similar cases experienced within the companies’ investments.
6.3.3.2 Technology selection

The process for selecting technology within the four companies has different criteria and conditions based on each company’s strategy and capabilities. Starting with Company A, according to the respondent, selecting technologies and projects for investment are based on the company’s experience in the industry and the company strategy. There is no formal process for the selection of a technology or project for investment; the company considers several key criteria and conditions in order to continue with the decision-making process. The process starts with the allocation of a special team to look for new opportunities to invest in. Company A also considers the following criteria for technology selection:

- The company allocates a group of skilled people to search and scan for new technologies and opportunities;
- The type of technology and its requirement is important for the project selection;
- The technology license is one of the critical factors that has an impact on the investment decision;
- The company always takes the cost of production as one of the technology selection criteria;
- The efficiency and the quality of the technology are extremely important issues because they are related to the quality of production;
- The state of the economy can affect the investment decision and the selection of the technology.

The selection of the right technology has a wide impact on the progress of Company A’s investment decision. For example, there are several factors that may be seen as difficulties when it comes to selecting the required technology, such as getting the appropriate license. This is one of the critical factors or problems that might delay the decision-making process. However, in some cases, the company will consider the possibility of entering into a joint venture or collaboration with the companies who own the necessary technology, which is sometimes the only way to get the license for certain
types of technologies. On the other hand, the company may face some difficulties in obtaining advanced technologies because of their lack of availability. The respondents considered this a critical issue for the progress of the investment decision, one that may mean a change in the decision process direction towards selecting a low quality technology.

*All of our investments depend on the type of the technology because today industries are based on technology. Selecting an investment depends on several factors and one of these factors is the required technology for the investment or the project.*

*Getting the license for the required technology and getting highly qualified and specialized consultants in our industry is one of the difficulties.*

CEO, Company A

To ensure that the investment decision is on the right path, Company A does not take the decision to select a technology or a project for an investment by itself. The company utilizes the services of partners and consultants in order to get the best possible advice and recommendations on the selected technology. However, Company A takes this step to avoid risk and to increase the success rate. At the same time, and during the selection of the technology, the company considers the expected benefits that the chosen technology will bring to support the operational justifications of the investment.

Company B’s main investments are in petrochemical plants, and because of the nature of these projects, selecting the technology is based on the project’s operational aspects and requirements, such as the infrastructure, utilities, and manpower. Within Company B, selecting the required technology for a new investment is part of the phase-three requirements, which is focused on identifying the project strategy and execution plan. To select the required technology, Company B assigns a process technology coordinator, i.e. an individual assigned to the project by R&D as the owner of the process of identifying, screening, evaluating and selecting the technology.
To invest in and introduce a type of technology, Company B takes into account a number of criteria based on the level of priority and the impact on the project value. The cost of technology is one such important criterion that could effect the investment decision. This is because the cost of the technology can play an important role in decreasing or increasing the total cost of the investment. This has forced the company to be very keen on controlling the investment cost to achieve successful investment. The company also considers health and safety and its related issues as a factor that can play an important role in selecting the right technology for the project.

*In the chemical industry and for our projects, the most important thing is the cost of the implementation and technology and to survive you have to control the cost or the project will face difficulties and failure.*

Executive Finance Vice-President, Company B

The level of difficulty in getting the licenses for the selected technologies is also a major issue for the progression of the investment decision. In some cases this forces Company B to build joint ventures and collaborations with other companies to obtain the required technology. This way of obtaining the necessary technology may change the project requirements and costs, which can then affect the requirements and plans for the next phases.

Selecting the best technology or an acquisition opportunity within Company C is a main step and element of the investment, which takes place after measuring the company’s financial potential and searching for opportunities based on location, technology and added value. The company starts the selection by producing a short list of the most attractive projects which have a higher return on investment and add value to the company’s future strategy. The selection of the best available investment opportunity is initially based on the outcomes from the pre-feasibility study report, which ends in selecting one or two investment opportunities; these potential investments will then be investigated further through in-depth feasibility studies. However, before conducting an
in-depth feasibility study for each opportunity, the company considers several factors and criteria for the selection stage. The first criteria for an acquisition case is the current state of the targeted investment, which is seen by looking at several important factors, such as the target company’s financial performance, its size, location and implemented technology.

The reason behind acquiring international companies is to acquire the technologies because they are not available in our area and they are difficult to license.

One of the technology selection criteria is measuring and understanding the technology value of the investment.

CEO, Company C

Based on the outcomes from the first selection criteria, Company C starts measuring and considering the target company’s management in terms of their level of flexibility, and there is communication in order to negotiate about their company’s situation. The aim of this step is to gain a better understanding of, and information about, the company’s value and level of readiness, which includes its technology, employees, infrastructure and the overall added value of the investment. In addition, the rules and regulations of the target company’s country are critical and must be taken into account, including the tax and change of ownership issues and, at the same time, the country’s political and economic environment. Company C’s investment trend is to invest in the global market instead of the local market. This is as a result of the lack of availability of the technologies in Saudi Arabia and the poor local investment environment, which are critical issues for the company.

In Company D, there are no clear criteria or decision-making process for selecting a required technology for a particular investment or project. Selecting the necessary technology is dependent on the nature and the requirement of the target project, while, on
the other hand, the project’s idea and requirements are dependent on the availability of feedstocks. This shows that the investment idea and the selection of technology are linked to the type of available resources, which is therefore considered the key element to the investment’s success. Once the type of available feedstock has been identified, the company specialists will try to look for the best way to exploit the natural resources by either expanding the current plants with new technologies or starting a new plant. In the case of expanding current plants and projects, the selected technology must be in line with the current operation and activities, so as to avoid any wide changes in the case of new technology for different activities, which could affect the current operations and workflow of the plants. For new plants, the company takes into account the project requirements, the type of feedstock and the feedstock sources, all of which play important roles in determining the cost of the investment.

For the selection of the technology, we try to identify the operational related issues such as manpower, operation cost, technology performance, maintenance, utilities and facility and the shipping port.

CEO, Company D

The cost of technology also plays a critical role in the selection decision, and this is related to the company’s financial state. In addition, selecting a type of technology for investment is linked to the possibility of obtaining the necessary funding and support from investors. The difficulty in obtaining the required budget for the selected technology may force Company D to look for different options, such as lower quality technologies, which may affect the overall performance of the project. Furthermore, the selection of the technology is based on the availability of the necessary manpower and skilled professionals to deal with advanced technologies and the project in general. This shows that the selection of a project or technology is linked to the company’s overall readiness towards new investments, which will be discussed in the next section.

The previous sections have covered the applied criteria, processes and factors considered in technology selection within the four companies by detailing and analyzing
respondents’ views and the company experience in implemented investment. The next section covers the aspect of company readiness and the considered factors and impacts identified by the respondents, based on similar cases experienced within the companies’ investments.

6.3.3.3 Company readiness and ability to invest

It has been observed that the aspect of readiness and the ability to invest is approached differently from one company to another in terms of measuring, understanding and increasing company readiness to make a new investment or to invest in technologies. On the other hand, company readiness and abilities to invest are affected by several factors and difficulties which cause a low level of ability to make investment decisions. For example, Company A does not consider the use of any tools or techniques to measure their readiness for investment. However, Company A’s strategy towards the ability to invest is achieving a certain level of performance, which can help the company to be ready for any changes or new investment decisions. For new investments, the company considers financial readiness and capability as a priority. The reason behind this consideration is the company’s previous experience of difficulties in convincing new investment financiers such as banks, governments and new investors, which is an important issue that may delay the investment decision or, in some cases, the implementation of the projects:

The ability to finance the investment is a really big issue because of the difficulties in funding investments and convincing banks about the company’s ability to handle the new projects and how to implement the project. Without all of these elements we will face difficulties in starting the implementation of the project and it is not only the implementation of the project because later on we will come to the operation of the project, which is all related to financial capabilities.

CEO, Company A
In addition to the company’s financial readiness and ability, the respondent claimed that the type of technology and its implementation is a critical requirement if the company did not have enough previous experience of a similar investment project. As a result of this, Company A is more focused on certain types of technologies and projects that allow limited expansion on similar activities investment. On the other hand, the company’s readiness in some cases can be affected by the difficulty in obtaining the technology license, which can lead to a delay in the decision-making process and to lost opportunities. According to the respondents, building and creating joint ventures with other companies who own the necessary technology is the only way to obtain certain advanced types of technologies; however, this method of obtaining the required technology increases the cost of the investment, which could have an impact on the company’s financial readiness.

Obtaining the license for the required technology and getting highly qualified people to run the technology are difficult because of the required high level of capabilities. However, we always consider the joint venture approach and options, which will give us access to resources and technologies from our partners.

CEO, Company A

To increase the company’s readiness for investment and in order to avoid possible risks, Company A does not take the decision on its own. Instead, the company utilizes the service of partners and consultants to measure its ability to implement the targeted technology or project and, at the same time, to identify the possible operational gaps that may have a negative impact on the investment. For example, the non-availability and difficulties of getting and finding important and essential resources such as chemical resources, feedstocks and utilities, and securing a location and infrastructure, are critical issues for the company, and they have a huge impact on the investment decision.

Determining the company’s readiness for an investment is a function that Company B continually takes into account in different phases with different levels. Company B starts
measuring its readiness and ability for new investment in the early phases of the decision process. This is done by estimating the expected cost of the project and comparing it with the company’s financial capability to invest. The respondents claimed that making sure that the estimated cost of the investment is under control is the most important factor that gives the company a positive intention to support the decision progress. This shows that the company considers its financial readiness and ability as the most important readiness factor to be able to solve all the other readiness and abilities issues:

The careful analysis of the external factors, such as the global economy and business environment, is a very important issue for investment success and the ability to invest.

Executive Finance Vice-President, Company B

In addition to financial readiness, Company B tries to make sure that the health and safety readiness is high enough to meet the international standards in order to start the project’s implementation process. This can raise some internal issues and factors such as people’s readiness for the new investment and their understanding of the technology and its requirements. It can also raise external issues and factors such as the local and global economic status and business environment, which may affect the company’s readiness to market the new investment. The respondent claimed that understanding several factors such as market size, demand, market growth and forecasting future trends is critical as it could affect the company’s readiness and its investment decision.

In Company C, readiness for new investments can be seen indirectly in the very early stage of the investment decision. The company measures the financial potential and the ability to invest initially, which shows that the company cares more about financial readiness than other readiness issues. The respondent believes that measuring the company’s financial ability is the key element and the most important issue in order to clarify the possible limitations and risks that the company could face during the investment.
To invest in a particular opportunity, first we look at our financial potential and ability to invest before we make any move. Based on our abilities, we start looking for opportunities and criteria.

CEO, Company C

Company C’s respondent also believes that, because of the company’s acquisitions investment strategy of buying and investing in plants in different locations, it needs to be at a particular level of financial readiness based on the facts of the investment opportunity. The respondents also claim that, in order to buy an attractive chemical plant somewhere in the world, immediate access to funds and prior budget allocation planning needs to be in place to avoid loss of opportunities, which clearly shows the importance of financial readiness. In addition, Company C faced difficulties in measuring its financial readiness because of poor and limited understanding of the financial options for the investment. Also, getting the necessary commercial loans or local loans from banks and investors is a great difficulty, which has a negative impact on the company’s overall readiness and delays the investment progress. On the other hand, the respondents claimed that the board members’ poor knowledge and awareness of the project’s facts and requirements is one of the great problems that relates to board readiness, which may affect the process of the investment decision.

One of the biggest issues is that if the company board members are not knowledgeable about the target acquisitions, it will make convincing them about the investment justification difficult.

CEO, Company C

Compared to financial readiness, the adopted acquisition strategy for new investment does not require a high level of readiness for non-financial issues such as people, infrastructure, top management and business processes. This is because Company C’s acquisition strategy is to look and search for an attractive investment opportunity with added value and positive position, which will help the company avoid any extra work that may be needed to the acquired plant.
Unlike Companies A and C, Company D considers the readiness and ability for new investment as the second critical issue after the availability of feedstocks. Although it is an important aspect, the company does not use any tools to measure its overall readiness, either before or during the investment decision-making process. Traditional ways of assessing the company’s state are applied before taking any investment decision, such as understanding the company’s performance level, which is the main source for information about the company’s readiness. With regard to readiness aspects within Company D, financial readiness is the most important and critical factor and is the main supporter of the company’s intention to make new investments. According to the respondent, understanding the company’s financial state and possible funding options are the drivers for new investment plans. The investment type and the nature of the resources are also linked to financial issues because they play a very important role in determining the required budget for the investment.

Because of the critical financial situation and other factors, Company D’s trend towards new investments is more focused on the local market, which explains the low awareness of, and readiness for, the available global options. The respondents claimed that the limited understanding and experience of the global economy and its potential investment opportunities are the main barriers to international investment. This demonstrates that the top management’s low level of maturity and awareness of the external factors is a significant issue, which could have an effect on the progress of investment decisions. Also, in several cases the company spent a long time understanding the available opportunities and options relating to new investments, which might have delayed the investment decision.

Although the government supports middle-sized petrochemical companies such as Company D, the complexity of the government rules and regulations is one of the major challenges for the decision process progress. The difficulty of getting confirmation or authorization for some of the investment requirements is a critical issue, which is related to the government’s readiness requirements. A wide discussion about government rules
and regulations will take place during the in-depth feasibility study to determine the company’s ability to meet the government’s conditions for new investments. Nevertheless, the difficulty in ensuring the project requirements themselves, such as availability of skilled manpower, advanced infrastructure, budget, suppliers and project leaders, is also one of the serious issues that may delay the investment progress, and is a big issue for the company. According to the respondent, ensuring the availability of skills, technical manpower and the market environment for an investment are major challenges; the main reason behind this apprehension is the shortage of local resources, which forces the company to look globally in order to guarantee these requirements. Moreover, the lack of experience in providing the required and appropriate training for an investment is a challenge for the company, which affects its readiness towards new projects.

*The readiness for the project is based on the project complexity level and the project requirement.*

*The readiness is also linked with the board members; in many cases the poor readiness of the board members to make a final decision is caused by their poor knowledge of the industry.*

CEO, Company D

In addition, Company D considers the communication with other partners is one of the significant issues in planning for the investment. According the respondent, the lack of communication with partners and suppliers could delay the progress of the investment, and this lack of communication is as a result of poor readiness during the initial planning for the investment, which may have a negative impact on the planning in general.

The previous sections have covered the aspect of companies’ readiness and ability to invest in terms of the process and factors considered and issues within the four companies. The next section presents the findings on the companies’ actions toward ensuring the alignment for technology investments.
6.3.3.4 Alignment

In general, most of the companies do not use any techniques or methods to create, measure and ensure the required alignment level for an investment or project implementation. In the case of Company A, the company deals with the alignment issues through traditional ways using particular techniques or methods. According to the respondents, the company’s wide experience within the petrochemical sector is the main tool for dealing with any internal and external issues related to alignment. Moreover, because of Company A’s experience and its large percentage of the market share, most of the company’s projects and investments are based on joint ventures and collaborations. The respondents claimed that these strong relationships between the company and other large companies were the key to fast alignments, because the joint experience and capabilities could solve most of the potential issues. For example, in some cases the company considers the joint venture path to get a license and support for certain types of technologies.

To ensure the best possible alignment between the targeted investment and the company, during the investment planning stage Company A undertakes contact and communication with contractors, consultants, and chemical companies. This provides a source of information from which to gather the necessary details about the technologies, their requirements and implementation processes. In addition, Company A takes into account issues relating to people and skills, which can be critical factors for the investment progress, applying a clear strategy with regard to the people and skills required by recruiting the necessary manpower and qualifications at the early stages of the investment in order to speed up the plant design process and equipment procurement.

Our experience in the petrochemical field and projects is the main tool to take the necessary actions and planning with regard to people, implementation, and technical requirements of projects.

CEO, Company A
As a result of the use of traditional ways and the lack of alignment techniques, the CEO claimed that the company faces difficulties and challenges in identifying the future capabilities of the technology and the project during the decision-making process. The difficulties in recognizing and forecasting several important factors, such as the market, competition, oil price, new technologies and the local and global economic trends, may affect the alignment between the company and the investment. The respondents said that these factors are very important and could change the decision direction. To support the investment decision-making process, Company A makes use of specialized consultants to forecast all the related issues and factors in order to create better alignment and avoid the possible risks.

Ensuring the alignment for an investment is also a function that Company B continually takes into account in different phases and at different levels. Company B considers that the alignment between the proposed investment and the company strategy is an important issue, which has priority before going forward. However, Company B’s main investments are in petrochemical plants, which gave it wide experience of all the possible gaps and challenges and how to solve any expected difficulties. On the other hand, the company is a source of resources, such as skilled people and natural resources and, as a result of this, resources are not a great issue. Although the company is a profitable organization, difficulties with obtaining and allocating the necessary funds from banks and the government are major issues that have a great impact on creating the necessary alignment:

\textit{In gate three we produce a bank’s feasibility study especially for banks to convince them about the project and its figure to obtain the required budget.}

Executive Finance Vice-President, Company B

As result of this, the company believes that controlling costs is the main driver for investment success. Furthermore, according to the respondents, external factors such as global economic trends and the business environment are important issues that should be analyzed carefully to increase the alignment. In addition, other factors such as market
size, demand, market growth and forecasting are critical factors that may affect the investment decision and the alignment. However, Company B is one of the biggest petrochemical organizations in the world and its wide experience is the main support for solving any alignment issue.

Within Company C, creating alignment is not key to the investment decision-making process. Because of the company’s investment strategy, which is acquiring other competitor’s plants, the company targets plants that are already well aligned internally with no major issues such as operational problems or a critical financial situation. The company believes that acquiring already well-aligned companies with no critical issues will help to avoid any possible risks that may affect the success rate of the investment. On the other hand, most of the alignment issues for the acquired plants are related to the performance of top management and the management style in these companies, which is considered to be a major issue that may have an effect on the overall performance.

According to the respondents, in many cases Company C utilized the services of specialist lawyers, and financial and marketing consultants before taking any decision, in order to ensure better progress of the investment. The reason behind this is that the company faces three major issues related to: the lack of awareness and understanding of the rules and regulations within the target country of investment; limited understanding of the financial options; and analysis difficulty in forecasting future market trends.

In Company D, creating the required alignment for investment is not a main step of the decision-making process. The planning for measuring and ensuring alignment is most likely not a clear task, but in most cases takes place during the discussion of the in-depth feasibility report and during the implementation stage of the investment, which carries with it more risks and challenges. However, the discussion of the feasibility report will include the major challenges for the investment and will identify the possible solutions for these challenges. The discussion focuses more on the financial issues and difficulties, such as securing the required loans, which is one of the greatest issues because of the difficulties in measuring the funders’ views and opinions, such as banks, governments
and new investors, which can turn into a major issue and may delay the investment decision.

_We invest locally because of the government support and because our understanding of the global economy is limited, which is a barrier to international investment._

CEO, Company D

Due to the lack of experience in global investments, most of Company D’s investments are local within the Gulf region. According to the respondents, the company trend is to invest locally because of the features and support that is provided by the government, which will protect the company investments as well as helping to ensure more alignment and, at the same time, avoid global risks. On the other hand, the respondents claimed that the government support is not always available at the right time and place because of the slow procedure, which may affect the overall alignment and success. For example, the initial strong promises from the government to supply the company with the agreed amount of feedstock will give the company the signal to start planning for an investment, but when it comes to the implementation stage the promises may not be achieved at the right time and place. This may put the company in a critical position that will force it to look for another supplier, with higher costs to ensure fast alignment. Nevertheless, to gain a better level of alignment, the company employs consultants and experts to support the planning and implementation stages by looking at the gaps and problems and suggesting possible solutions.

The previous sections have presented the findings of the companies’ actions toward ensuring the alignment for technology investments. This section has also discussed factors and issues that could inhibit achieving the necessary level of alignment within the four companies. The next section covers the findings of the four companies towards understanding and realizing the benefit of the investment identified by the respondents, based on similar cases having been experienced within the company’s investments.
6.3.3.5 Benefit realization

Realizing the benefit of the investment is considered a priority for the four companies during planning for the investment and when taking the final investment decisions. Realizing the benefits of the investment are conducted in different ways and methods based on each company’s interest and targeted benefit. The estimation of the investment benefits in Company A is based on applying a number of traditional techniques, as it is considered by the company CEO as a gap in the decision-making process. However, the company does identify the benefits of the investment in the early stages and during investment planning by analysing several external factors related to the investment. The company believes that identifying these factors will help to determine the targeted benefit from the investment. Examples of these factors are:

- The type of technology and its relation to the cost and quality of production;
- The total cost of the investment;
- The availability and price of resources, such as chemical resources, feedstocks and utilities;
- The level of success for marketing the new investment;
- Future capabilities (i.e. of market, competition, oil price, new technologies, economy) is important to recognize the forecasted benefits and difficulties;
- Changes in the market share and the global economic trend.

Company A claims that the level of accuracy of these identified factors will lead to a better understanding of the expected profit and the possible risks, which will reflect in the investment decision.

Identifying and understanding the expected benefit from an investment by Company B is the main task that needs to take place during stages one (Concept rationalization and pre-feasibility) and two (Feasibility and venture philosophy) before progressing to stage three (Project strategy and execution plans). Planning to realize the benefit from an investment is necessary in order to progress the decision process. However, getting the initial
approval for an investment must pass a very critical stage, which is the estimation of the targeted benefit. According to the respondents, to take an investment opportunity forward, the investment has to have an internal rate of return (IRR) of more than 15%. If the investment doesn’t achieve an IRR of 15% or more, it will be rejected.

Estimating and realizing the benefit from the investment within Company C is conducted by using traditional and basic methods. The company only calculates the benefit of the investment twice during the investment decision-making process. Firstly, when searching for attractive opportunities for investment, the company identifies the proposed benefits and risks of all the suggested potential opportunities, which will be presented in the pre-feasibility study report. Based on the outcomes of the report, an opportunity for investment will be selected, based on the level of the identified initial added value of each investment opportunity. After selecting the most appropriate investment opportunity, a detailed estimate will be presented in the in-depth feasibility study, which will clarify specific details about the expected benefits.

Company C believes that the outcomes of these two benefit analyses should give a clear picture and forecast of the targeted investment. However, in some cases, after making the final decision, the estimates and expectations of the investment benefit may prove not to be accurate. This is due to several internal and external factors, such as the use of traditional estimation and forecasting methods, poor awareness of external factors, economic rules and regulations of the investment country, global economic trends, production cost and customer requirements.

Estimating the expected benefit from an investment opportunity within Company D takes place in two stages of the decision-making process. The first stage is when the company estimates the initial benefit of an investment opportunity by conducting a brief assessment before the selection stages. The brief assessment includes an analysis of several important factors such as supply and demand; the respondents claimed that
In the brief assessment we look at supply and demand, target market, we look to these issues from a strategic view and what are the short and long term benefits, for example from polypropylene and polyethylene, and what is the global demand in the last and next few years.

Respondents, Company D

Based on the brief assessment outcomes, an initial decision will follow to carry on to the next stages of planning for the investment. The company then measures the expected benefits for a second time before making the final decision. At this stage the company measures the benefits in depth by conducting an optimization, a technique that defines the expected performance, profit and risks. Based on the results from the optimization, a final decision will be taken before the implementation stage. However, the result from the optimization technique may not give a very clear picture of the expected benefits; according to the respondent, the reason behind this is the difficulty in understanding and forecasting some of the external factors such as market trend, customers and competitors.

6.4 Summary of findings

The analysis of the first study demonstrated that companies have different and strategies toward technology investment decision. Based on the analysis of the data and the review of the literature, the results were categorized into headings. This section aims to present and discuss several tables that contain issues and factors affect the technology investment decision making process. Table 6.2 summarises the findings from the first research study related to investment justification.
### Investment justification

<table>
<thead>
<tr>
<th>Issues</th>
<th>Companies findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology cost</td>
<td>Company A: Understanding the impact of technology cost on the total cost estimates is a priority during the decision-making process because of its impact on financial ability. Company C: The difficulties in licensing the technology needed affect the cost of the project. Company D: The high cost of the technology needed; forced to look for different options with lower cost and quality.</td>
</tr>
<tr>
<td>Analyzing the technology performance</td>
<td>Company C: The company acquisition strategy helps to understand and estimate the technology operation cost and to avoid any unknown risks. Company B: Estimating the technology operation cost and its impact on the total investment cost is a critical issue in justifying the investment.</td>
</tr>
<tr>
<td>Lack of understanding factors</td>
<td>Company B: The difficulty in understanding all aspects of the investment idea is a critical issue that caused a delay in the decision process. Company C: The difficulty in convincing the company board about the proposed investment is an issue that could delay the investment decision and result in lost opportunities.</td>
</tr>
<tr>
<td>Poor forecasting and lack of information</td>
<td>Company A: The shortage of information and difficulties in measuring and forecasting the future factors such as the market, competition, oil price, new technologies and global economic trends, could have an effect on the decision process. Company B: The lack of clarity on the financial information and estimation caused difficulties in justifying the investment financially. Company D: The lack of information and experience in understanding the global economy is a barrier to the company to invest internationally.</td>
</tr>
<tr>
<td>Estimating and planning for project requirements</td>
<td>Company A: The cost of the necessary resources such as chemical resources, feedstock, utilities, securing a location and infrastructure is a critical issue for the company and one that has a huge impact on the investment decision. This issue is also considered within the operational and strategic justification. Company D: Poor planning and failure to exploit the feedstock and government support are the main factors that could affect the decision-making process, leading to an overall failure.</td>
</tr>
</tbody>
</table>

| Table 6.2: Investment justification findings from Study One |

In summary, justifying the investment between companies is based on several elements, such as the management style and investment strategy, and the process of making the decision. It has been observed that most of the companies are focusing on justifying the investment financially as a priority. Therefore, the investment decisions are based more
on financial figures and facts rather than on strategic or operational facts. However, justifying the investment is also linked with the other elements of the decision-making process. Table 6.3 summarises the factors related to technology selection.

<table>
<thead>
<tr>
<th>Technology selection</th>
<th>Companies findings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Issues</strong></td>
<td><strong>Companies findings</strong></td>
</tr>
</tbody>
</table>
| **Technology licensing** | Company A: The technology license is one of the critical factors that has an impact on the investment decision. This may cause a delay and force the company to build a joint venture or collaboration with the licencers.  
Company B: The difficulty in getting the licenses for the selected technologies is a major issue for the progression of the investment decision. This may change the project requirements and costs to obtain the required technology. |
| **Operating the technology** | Company C: Operating the selected technology may face some obstacles such as the rules and regulations of the country and the political and economic environment.  
Company D: Issues with operating the technology are strongly linked with the availability and type of feedstocks and chemical materials. |
| **Evaluating the technology** | Company A: Understanding and evaluating the efficiency and quality of the technology are extremely important issues because they are related to the quality of production. |
| **The non-availability of the required technology** | Company A: The lack of availability of technology is a critical issue that may cause changes in the decision-process direction towards selecting a low quality technology.  
Company C: The lack of availability of the technologies in Saudi Arabia and the poor local investment environment are issues for the company. |

Table 6.3: Technology selection findings from Study One

Selecting the required technology for the project is the main issue for petrochemical companies in making the investment decision as the project’s activities and operations are all based on the technology. As the Technology selection table summarizes, companies are influenced by several factors and issues that affect their process to select the most appropriate technology for the project. Internal and external factors such as licensing, evaluating and operating the technology are some of the issues that may result in changes
to the criteria followed to obtain the required technology. Selecting the technology is also linked with the companies’ ability and readiness to conduct and manage the investment. Table 6.4 summarizes the Readiness issues toward technology investment.

<table>
<thead>
<tr>
<th>Readiness</th>
<th>Companies findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Issues</td>
<td></td>
</tr>
<tr>
<td>Ensuring the investment requirements</td>
<td>Company A: The financial readiness and capability considered as a priority to determine the company's ability to ensure the investment requirements. Company A: The non-availability and difficulties of obtaining the essential resources such as chemical resources, feedstock and utilities, and securing a location and infrastructure are critical issues for the company, and they have a critical impact on the investment decision. Company C: Measuring the company's financial ability is the key element and the most important issue in order to clarify possible limitations and risks that the company could face during the investment. Company C: The difficulties in measuring its financial readiness because of poor and limited understanding of the financial options are affecting ensuring the investment requirements. Company D: The investment type and the nature of the resources are linked to financial issues which are reflecting the company’s ability to ensure the investment requirements.</td>
</tr>
<tr>
<td>Complexity with marketing</td>
<td>Company D: The company’s new investments are more focused on the local market due to the lack of readiness for the global market.</td>
</tr>
<tr>
<td>Readiness toward technology</td>
<td>Company A: The type of technology and its implementation are issues that the company experienced in a similar investment project.</td>
</tr>
<tr>
<td>People readiness</td>
<td>Company B: Internal issues and factors such as people’s readiness to work with the technology and their understanding of the technology and its requirements are critical factors. Company D: Ensuring the availability of skills and technical manpower are major challenges; the main reason behind this apprehension is the shortage of local resources, which forces the company to look globally in order to guarantee meeting these requirements.</td>
</tr>
<tr>
<td>Lack of communication</td>
<td>Company D: The lack of communication with partners and suppliers could delay the investment’s progress, and this lack of communication is a result of poor readiness during the initial investment planning.</td>
</tr>
<tr>
<td>Company board knowledge</td>
<td>Company C: The board members’ poor knowledge and awareness of the project’s facts and requirements are the main problems that relate to board readiness.</td>
</tr>
</tbody>
</table>

Table 6.4: Readiness findings from Study One
As has been observed, the level of readiness within each company is different based on the capabilities of each company. It has been found that companies are concerned about several issues that are related to readiness toward investment such as manufacturing, operation, people and most importantly the financial readiness towards investment. The financial readiness and its issues and factors are found to be more critical to many organizations than the other issues. In addition, several external factors such as the market situation and communication with partners are also issues that may affect the investment decision process. To ensure readiness and to increase company capabilities toward investment, petrochemical companies work on creating the required alignment by finding the most appropriate solutions. However, creating the required alignment is also affected by several difficulties and factors which are summarized in Table 6.5. Internal and external issues were found to be barriers to petrochemical companies’ attempts to achieve the business objectives from investments in technology.

<table>
<thead>
<tr>
<th>Issues</th>
<th>Companies findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building a joint venture</td>
<td>Company A: Most of the company’s investments are based on joint ventures and collaborations to avoid the high risks.</td>
</tr>
<tr>
<td>Difficulty with marketing</td>
<td>Company B: Issues such as the market size, demand, market growth and forecasting are critical factors that may affect the investment decision and the alignment.</td>
</tr>
<tr>
<td>Lack of information</td>
<td>Company A: The lack of information caused difficulties in understanding forecasting several important factors, such as the market, competition, oil price, new technologies and local and global economic trends, which affected the alignment between the company and the investment. Company C: The company utilized financial and marketing consultants before taking any decision, in order to ensure better progress of the investment.</td>
</tr>
<tr>
<td>Shortage of resources</td>
<td>Company B: The difficulties with obtaining and allocating the necessary funds from banks and the government are major issues that have a great impact on creating the necessary alignment.</td>
</tr>
<tr>
<td>Controlling the investment cost</td>
<td>Company B: The company believes that controlling costs is a factor in achieving successful investment. Company D: The financial issues and difficulties, such as securing the required loans, which is one of the greatest issues, can turn into major issues and may delay the investment decision.</td>
</tr>
</tbody>
</table>

Table 6.5: Technology alignment findings from Study One
In addition to the previous issues discussed, realizing the benefits of the investment is also a critical and important issue for petrochemical companies during the decision-making process, and varies from one company to another. Although most of the companies are using traditional techniques to identify the investment return and benefits, companies apply different criteria as a basis to understand and estimate the outcome of the investment, such as the availability of materials, infrastructure, market demand and government regulations. On the other hand, several factors and difficulties are found to be barriers to the realization of benefits, such as the difficulties of forecasting the market and the technology performance, which could affect the return on investment (ROI). These issues are summarized in Table 6.6.

<table>
<thead>
<tr>
<th>Benefits realization</th>
<th>Companies findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identifying the benefits and risks in the early stage</td>
<td>Company A: Understanding the benefit of the investment in the early stage is the main key for the approval of the investment.</td>
</tr>
<tr>
<td>Identifying the expected benefit base on the technology type</td>
<td>Company A: Identifying the benefits of the investment is based on the type of technology and its relation to the cost and quality of production.</td>
</tr>
<tr>
<td>Difficulty with forecasting understanding of some factors (ex. market share, financial options)</td>
<td>Company C: The difficulty in identifying the investment return and benefits are caused by several internal and external factors, such as the use of traditional estimating and forecasting methods, poor awareness of external factors, economic rules and regulations of the investment country, global economic trends, production cost and customer requirements. Company A: The future capabilities (i.e. of market, competition, oil price, new technologies, economy) are important to recognize the forecasted benefits and difficulties. Company D: The reason behind this is the difficulty in understanding and forecasting some of the external factors such as market trend, customers and competitors.</td>
</tr>
</tbody>
</table>

Table 6.6: Benefit realization findings from Study One
6.5 Summary

This chapter has presented the first study findings of an individual analysis of four petrochemical company case studies with the intention of identifying and analyzing the applied decision-making processes and five different aspects that relate to investment decisions and justifications, technology selection, company readiness, alignment and benefit realization. It was observed that, while the management style and organizational context of the four companies were different in several cases, all four companies shared some common characteristics with regard to petrochemical technology investments.

However, the decision-making process in each company did not always take account of some of the important issues and elements that might change the direction of the investment decision. In terms of the decision-making process, the lack of a documented decision process in most of the interviewed companies in the first study was a concern and created an unclear vision of what the possible gaps are in the petrochemical companies’ investment decision process. The first study highlighted the factors and difficulties without gaining in-depth data about the facts. Therefore, a second study based on project level was required to understand and identify the causes of the difficulties and what may influence the technology investment decision.

The next chapter will present the findings of the second study and provide an in-depth cross-case analysis of the five elements of the decision-making process.
Chapter Seven
Project level investigation of factors and difficulties affecting technology investment decision making
Chapter Seven
Project level investigation of factors and difficulties affecting technology investment decision-making

7.1 Introduction

As the aim of the first study is to investigate the investment decision-making process within the petrochemical companies at an executive level, the results highlighted the executives’ thinking toward the issues and factors affecting technology investments. Therefore, it was important to investigate in-depth the factors and difficulties found, to understand better what could affect successful technology investment. For the in-depth investigation, the second study was conducted on a project basis by targeting the people in planning responsible for investment decision-making, such as project managers, finance executives, operational managers and business developers. Targeting this group of respondents allowed flexibility in terms of time and meeting arrangements, which allowed the researcher to raise issues and investigate thoroughly.

The aim of this chapter is to present the findings and analysis of the second study conducted, which provides a more detailed investigation of four petrochemical companies in Saudi Arabia. To support the findings from the first study, the second study interviews investigated in-depth the results from the first study, which have been discussed in detail in the previous chapter. This investigation is based on the methodology presented earlier in Chapter five. The second study aimed to investigate petrochemical technology investment by focusing on understanding and identifying the companies’ decision-making processes and the factors and difficulties that they faced while planning to implement new technologies and embark on project investment. Investigating the above issues specifically focused on a number of critical elements of the decision-making process: 1) investigating the investment benefit-realization process. This
was undertaken to explore the factors that these companies considered while reaching their decisions; 2) to ascertain how investment justifications are identified and the factors that may have influenced the direction of the decisions made; 3) the criteria considered in the technology selection process and the difficulties that the companies faced; and 4) how these companies manage their abilities to invest, and the actions they undertook to increase their readiness.

The analysis and findings of the first study interviews presented in the previous chapter aimed to explore the technology investment decision-making process and the factors that impact the success of the investments. Based on this initial exploration, the analysis of the findings were used significantly to design the questions of the second study to understand better with in-depth detail the impact of the identified factors and difficulties that may affect technology investment decisions. A comprehensive case study approach was adopted to provide more valuable findings about what influenced the companies’ investment decision-making.

The results presented in this chapter are based on interviews conducted with the representatives of four companies who are involved widely in the planning of their company’s investment decision-making. This chapter begins with an analysis of the company decision-making process, followed by addressing the data from each company and providing inter-company comparisons, analyses, and reviews with respect to the research objectives and questions. It concludes with a summary of the findings and some answers to the questions proposed in this study’s research agenda.

### 7.2 The design and planning of the Second Study

Based on the analysis and findings of the first study, it was necessary to investigate the results in-depth by conducting a qualitative case study to explore the impact of the findings, the difficulties and their impact on the direction of the technology investment decision-making process. The first study results, the analysis and the experience obtained
from the interviews, was important and was considered as a point of reference in the second study. In addition, the findings from the first study contributed to the design of the second study to improve the clarity and the quality of the collected data. The second study focused on several specific areas:

1. The technology investment decision-making process

2. Technology investment benefits realization and process
   - The process and stages of realizing the benefits
   - The factors/difficulties that inhibit/contribute to realizing the investment benefits
   - The impact of the factors/difficulties on the investment decision
   - The companies’ actions toward managing the benefits

3. The investment justification process
   - The applied process for justifying the investment
   - The factors/difficulties that inhibit/contribute to justifying the investment
   - The impact of the justifications on the investment decision-making process

4. The technology selection process
   - The applied process and criteria for technology selection
   - The factors/difficulties that affected selecting the technology
   - The impact on the investment decision-making process

5. The company abilities toward technology investment
   - The issues and factors affecting the company abilities and readiness to invest
   - The company actions towards increasing the abilities to invest successfully.
Semi-structured interviews were applied in all the interviews to allow the respondents to speak widely about their company’s experience. The questionnaire was designed to ask each respondent to choose a successful and an unsuccessful investment that their companies went through, to be considered as cases for this research study (see Appendix two). Investigating successful and unsuccessful investments aimed to support the second study strategy, which is based on a project level investigation to provide better understanding about the decision-making process and to allow the researcher to carry out a comparative investigation of the petrochemical technology investments.

For the second study, eight interviews were conducted with the same four selected companies in the first study. Interviewees were identified with support from the interviewed respondents in the first study, based on the availability of the people who are involved in the investment decision-making process. A range of people including business developers, project managers, marketing executives and finance executives were selected as participants for the second study. Most of the interviewees are experienced and involved widely in making the companies’ investments decisions. Table 7.1 shows the targeted interviewees in the first and second study.

For the purpose of the second study, 12 different projects were investigated with four companies. The second study includes information from 8 unsuccessful and 4 successful investment decisions. The Decisions perceived as ‘unsuccessful’, included: rejected; decision making process not completed; difficulties in making the decisions; not satisfied with the outcomes of the expected benefits; or the project returns were not as high as expected. The interviewees had the choice to select the projects to investigate. On the other hand, successful investments were based on the level of satisfaction of benefits and the ease of the decision-making process. The analysis of the case studies was conducted individually, firstly by analysing successful and unsuccessful separately, followed by identifying the similarities and differences.
The analysis adopted techniques from Eisenhardt (1989) and Yin (2003) for cross-case analysis and started by categorizing similarities and between-group differences. The categorizations of the results are followed by comparisons of the findings and an investigation of the impact of five elements in the decision-making process. The presentation of the analysis takes into account the aims of the interview questions and the research aims and objectives. For each element, the analysis considers three different paths to display the findings. These are:

1. The decision making process;
2. Factors and difficulties faced during the decision process;
3. The influence of these identified factors and difficulties on the decision process.

<table>
<thead>
<tr>
<th>Company</th>
<th>First study Interviewees</th>
<th>Second study Interviewees</th>
<th>Investigated projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>CEO</td>
<td>Business Developer</td>
<td>Successful + Unsuccessful</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Marketing Executive</td>
<td>Unsuccessful</td>
</tr>
<tr>
<td>B</td>
<td>Executive finance</td>
<td>Senior Project Manager</td>
<td>Successful + Unsuccessful</td>
</tr>
<tr>
<td></td>
<td>Vice-President</td>
<td>Senior Project Manager</td>
<td>Unsuccessful</td>
</tr>
<tr>
<td>C</td>
<td>CEO</td>
<td>Marketing Executive</td>
<td>Successful + Unsuccessful</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vice President Finance</td>
<td>Successful + Unsuccessful</td>
</tr>
<tr>
<td>D</td>
<td>CEO</td>
<td>Senior Vice President</td>
<td>Unsuccessful</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Finance</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Business Developer</td>
<td>Unsuccessful</td>
</tr>
</tbody>
</table>

Table 7.1: The Interviewees in the first and second study
7.3 Investment benefit realization

In the following sections, a cross-case analysis and discussion is presented on the applied benefits-realization process within the four companies. In addition, we analyze some of the issues that may have affected these companies when planning to realize the benefits of their investments, and how these issues may affect the direction and progress of their investment decisions.

7.3.1 The benefit-realization process and management

Knowing the return from an investment is one of the most important priorities that company decision makers must be aware of before reaching their final investment decision. For the petrochemical industry and its companies, the planning exercise to understand the benefits from a proposed project can take place at different stages during planning the investment decision-making process; it must take into account a number of factors to identify the possible benefits from the investment. In all companies, realising the investment benefit is supported by business financial models which in a feasibility study are used to justify the investment financially. The financial model must provide an estimate of several important figures that could play an important role in forecasting the investment benefits. For example, in Company A the financial models are based on several elements such as calculating the labour and raw material costs, the expected price for the product, and the expected operating rates at the plant. The effectiveness of such financial models is also based on analysis of the relevant market and of their customers’ demand. Applying these models and noting their limitations must enable companies to clarify their internal rate of return (IRR) and the feasibility of their investment, based on the company’s strategy.

For companies A, B, and D realising the initial benefit from their investment cannot be undertaken without analysing the availability and the utilization options of the inputs (such as chemical materials) which are considered a key element in implementing the investment decision successfully. However, Company C considers understanding the
investment’s financial aspects and the initial design of the project as the first stages of the realization of the benefit of the investment.

For a petrochemical project, we can’t start planning for a project without knowing the availability of the inputs. The investment benefit can be identified initially from the availability of the raw material inputs.

Company A, Business developer

In companies A and C, understanding their capabilities—including the availability and the locations of the raw material inputs—is an important task that must take place during the screening and evaluation of investment opportunities. The early analysis of their material input capabilities and options is an important element for the beginning stage of their decision-making process; it is essential information to support the financial analysis of investment for companies A and C. In addition, understanding the supply of raw materials can give the companies an initial picture of the possible revenues and the expected profits from their investments. Also, companies A and C claim that knowing the input options can help to show them what level of strategic benefits the investment could provide and how this can be linked to their company’s strategic planning trend.

A little differently, Company B considers early identification of the “constructability” of the project as an important process to support the realization of the benefit. Constructability is a project management concept used to measure the company’s ability to design and build a project, including the construction of the project, and the capacity to provide the required resources for the project. Understanding constructability can help the company to identify possible obstructions and problems before the start of the project. For Company B, its thermoplastic olefins project’s constructability was a serious issue that affected the company’s ability to utilize the project’s technology. Determining the likelihood of constructability is an important and critical process, linked strongly to a marketing study and to the selection process for the technology, all of which could influence the investment benefits.
Realising the benefit from the investment through a number of stages is undertaken through different processes and steps based on the nature of the investment. In Company C, the strategy for new investment was based on acquiring established business. Here, the aim is to buy a company operating in the same field to achieve faster growth instead of starting a new project from scratch. To realize the benefits from a targeted acquisition, Company C starts the acquisition process by conducting a due diligence study to assess their planned investment. In the case of the company’s titanium acquisition—and because the size of the investment reached $1.2 billion—the company started a due diligence study using internal and external consultants to understand the accessed information for a better realization of the benefits. The due diligence study was controlled by three different dimensions to achieve a better realization of the benefits. The first dimension was the financial benefit from the investment, which was analysed using traditional methods such as NPV (Net Present Value) and IRR. This was followed by a second dimension, which is the analysis of market share and the possible marketing benefits from the investment. The first two dimensions are based on a third dimension, which is the value and evaluation of the available technology in the company targeted for acquisition. Understanding the capability of the technology is considered the key to the realization of the financial and non-financial benefits to support their investment decision.

Determining the benefit of the investment for Company D is based firmly on forecasting market demand. Forecasting customer demand and the likely potential of the investment are found by applying a traditional analytical method based on available information on the market, the customers, and suppliers. The company claims that forecasting demand must be conducted in the early stage of the decision-making process to identify the expected value added of the proposed investment. In Company B, the IRR and ROI (Return on Investment) should meet the designated financial criteria, otherwise the company will take the project through a different process called “recycling”. This aims to re-evaluate the benefit by analysing the benefit again for more accurate data prior to decision making. In the next section, we analyse different internal and external factors
and some difficulties that can occur while identifying benefits that may influence the final decision.

7.3.2 Factors and difficulties affecting decision making

In petrochemical investment, several factors and difficulties that may occur can be internal or external and may appear during the decision-making process. Factors related to financial, technical, and managerial issues have been faced in all of the four companies before and during their investment planning. Company A, in realising part of the investment benefit of the company, found that the hydrocarbon downstream project was affected by a lack of availability of information about the product and the global market trend. This caused a lack of clarity about the market’s growth and thus about the likely benefits. In addition, understanding the benefit to Company B of the thermoplastic project was a critical issue because of their difficulty in forecasting product demands, customers, and the possible growth path of the market. Their difficulty in understanding the investment benefits from the market trend was not only linked to the lack of market information, it was also caused by the company’s poor ability to analyse and investigate certain elements of the market and the available information. As was the case in Company D, the difficulties with analysing Asian market demand in the propylene and polypropylene markets were caused by the lack of experience of the project team and their inability to identify the correct ROI; this affected their analysis of the market and its customer demand.

A lack of experience in Company C with a poor understanding of petrochemical mining projects were two of the great difficulties that affected the realization of its investment potential and benefits. Company C’s lack of experience in the investment field caused them difficulty in estimating the available raw materials in the acquired site for the mining project, which in turn affected their determination of the likely benefits of the project. The inaccuracy of the information provided by the seller about the acquired company’s petrochemical mining operational capabilities was a critical factor too. The information needed to analyse and estimate the production capacity of an investment that
was considered a very high-risk one affected the realization of the benefit. In another case, Company A’s poor experience with the hydrocarbon upstream products presented great difficulty for them in being unable to understand the benefit level of the project at the beginning stage of their decision-making process.

Estimating the overall cost of Company B’s thermoplastic and hydrocarbon project presented great challenges for the investment process and thus for the realization of its benefits. The high cost of both projects ($1.8 billion in total) was considered hard to analyse, which caused difficulty too for the company to conduct the feasibility study for the project. The difficulties in realising the expected benefits of a project with a very high cost was the critical issue that forced the company to re-estimate and to recalculate the cost of the project, while changing the project definition to achieve a reasonable cost with potential for benefits.

The difficulty with estimating the project cost to realize its investment potential and benefits was also caused by the selected technologies and equipment for the project. Company B’s selection of the technology for the thermoplastic olefins unit played an important role in their difficulty in estimating the cost and benefits of the project. The difficulty with selecting the technology was caused by such factors as the licensor’s complex negotiation process, terms, and the conditions to authorize the technology for investment. Among the conditions was the sharing of a percentage of the investment benefits and profits with the company to authorize the technology. This was a critical factor that Company A faced in both projects, and which affected the company’s expectations about estimating the investment costs, benefits and risks. Any difficulty in analysing information related to the technology’s expected performance was critical. It was an issue that could influence the achievement of the targeted benefit from the investment. For example, it was difficult for Company B to analyse the information and the performance of a petrochemical technology needed to produce automation products. This included analysis such as the technology infrastructure requirements, the technology specifications, and the link between the technology’s performance and their production capacity. It was also difficult to assess the quality of the output produced from the
technology, and its maintenance and operational costs. The analysis of these issues played an important role in realising the investment benefits.

*It was difficult to know and estimate the final cost for the project. The project went through different phases; there were price increases for some equipment, and the price of some materials such as steel and other raw materials became more expensive; this caused higher costs than we expected and because of that we didn’t estimate the cost correctly.*

Company C, Business developer

Selecting the best technology for Company B’s thermoplastic project was difficult because of the complexity in understanding the market trend and the investment requirements. This forced them to conduct an extensive marketing study, in view of the company’s aim to introduce a new product to the market. This made planning to estimate the benefit from the selected technology a difficult task due to its link to production and thus to the quality of the product.

The perception of the investment benefit is also affected by internal performance and the companies’ capabilities. The performance of the planning team and experts within a company can be the key to realising the benefit accurately. However, poor understanding between teams can be a critical issue that may hinder the realization of the investment benefit. Issues such as the adopted working methods and style can be negative factors that may affect the decision-making progress. Further, disagreements between and within teams about a project’s definitions and specifications can be critical to the investment outcomes.

*We had a disagreement in project A on what was the best location and what were the most benefits that we could gain from different locations, and we had a disagreement between people about the best location. And the same*
issue happened with setting the definitions of the project. Despite these disagreements we were trying to achieve a cost-effective project.

Company B, Project manager

Time to make the investment decision and to start the implementation was a great concern for companies B, C, and D and it affected the accuracy of their decision outcomes, the planning for their projects, and the realization of the investment benefits. The issue of time in Company C was that it involved estimating the required time to complete the project and its impact on the investment benefits. This was difficult to determine because of the delivery delay of the necessary equipment and the lack of technical support from the suppliers.

We had some difficulties with measuring the benefit of project B because of the licensing issues, but it ended with a successful negotiation. But in project B we were required to make a final decision in a short time, which then made the identification of the benefits hard for us. Also, we had limited time to make a plan to utilize the raw materials stock to maximize the investment benefits.

Company B, Project manager

In project B we applied a specific process to identify the benefits but we were worried. This is because of the lack of accuracy, as we had to make a decision too quickly.

Company C, Senior Vice President Finance

The design and the knowledge of the project’s technical aspects are critical factors that could have a substantial impact on a project’s potential and decision directions. Company C found it hard to evaluate the operational performance and the technologies of the acquired companies, because of their difficulties in visiting all eight sites in a limited
time. In addition, the company faced problems with their planning to design and expand the operations in the mining project, which affected their estimation of the benefits of the investment. Further, the realized financial benefits for Company C’s sodium silicate project were not as the company expected. The reason was their poor cost estimation and marketing, and some technical issues caused by the lack of resources, the technical specifications of some equipment, and the appropriateness of the materials, particularly problems related to quality assurance. The availability and type of raw materials are important factors that can affect operational designs and project performance, and are reflected in the benefits and the level of investment. In addition, the difficulty in finding the most appropriate location with advanced utilities was an important factor for the ROI. The lack of a good location with advanced utilities for Company B’s hydrocarbon chemical production project forced them to look at a different location within the kingdom. This dramatically increased the investment implementation cost, and caused a reduction in the possible returns and benefits of the investment.

A lack of awareness of some external factors, such as government rules and regulations, including legal issues, could have affected the ROI. For Company C, understanding the tax and financial rules and regulations for titanium acquisition in Latin America was a difficult task. This was due to the differences in culture and government politics, which caused difficulties and misunderstandings during the analysis of the financial figures, including the expected benefits. In a similar situation, identifying the benefit for Company D’s propylene and polypropylene plant was affected by the market regulations of a number of Asian countries such as India and China. The changes in the regulations by India and China toward the import of chemical products such as propylene and polypropylene contributed to a lack of vision by Company D on the possible risks and the long-term benefits.

*We tried to do the consultants’ work by ourselves and faced many problems and issues. But we used legal advisors, tax advisors, and financial advisors, and we also worked and the technical people worked too.*
Awareness of the global economy and trends in the petrochemical industry was important for the success of the project. Company A’s realization of the benefits for its hydrocarbon project was based on a projected level of strategic growth and the development of each investment. The strategic growth had to meet the company’s desired expectations for the short and long-term trends to deliver financial benefits. The company adopted this strategy because of the current trend of the petrochemical industry. The company business developer claimed: “There are many petrochemical projects and products declining in investments from year to year; we can see this now because many plants are closing”. It was difficult for Company A to estimate the investment potential of its project during the planning stage of the thermoplastic olefins unit project. Changes in the market affected their expectations of benefits and growth; this caused a loss of opportunities in different investments. External factors related to contractors and suppliers were considered critical factors that could have an impact on the project implementation timeline, and which may have affected the expected return from the investment. Company C’s sodium silicate project was affected by the missed delivery of equipment specifications and poor commitment from the suppliers, which caused confusion during planning for the implementation stage and changes in the benefits level.

Several internal and external factors contributed to gaining a better understanding of the investment benefits and returns during the decision-making processes and thus played important roles. External factors such as the availability of a location with advanced infrastructure for Company B’s hydrocarbon plant were important aspects that helped the company to make effective plans for the utilization of their raw material inputs. This planning enabled the company to realize the possible level of competitive advantage that the investment might yield. It supported them in understanding what type of benefits the location could provide. Utilizing the assistance of industry expertise and external consultants were also considered to add value to the investment, and they played an important role in planning for it. Companies A and C’s utilization of external consultants in the hydrocarbon unit and the sodium silicate project was a key factor for understanding
the financial and legal issues better, in addition to the technical studies which helped them to clarify the investment details and benefits. Completely contrary to the experiences of companies A and C, the inadequate utilization of consultants and experts in Company D was a reason behind their poor identification of the propylene and polypropylene plant potential to supply the East Asian market; this therefore affected the company’s realization of the possible benefits from the East Asian markets.

Knowing about gaps in the petrochemical industry and its market was considered one of the success factors for Company C’s titanium plant acquisitions. The company’s extensive study of the market shares and its main players was the key to the investment decision because of their expected benefits from entering this market. This was supported by the state of the world economy and the prices of the required raw materials for the project operations, which made assessing the expected benefits from the investment easier for the company. Internal performance during planning for the investment decision was an important factor for the success of the investment. Company B’s hydrocarbon chemical production plant was a successful project that achieved more benefits than were expected. The reason for this was the high quality of their planning and the team’s performance in defining project aspects, such as the cost estimation and the technical data to justify the investment. Senior management support and commitment towards the investment in Company C’s sodium silicate project was a critical success factor that contributed to the decision-making process and to the realization of the benefits.

*Even with these difficulties, the top management’s commitment and support contributed to the project; we also used consultants who supported us to understand the benefits better.*

Company C, Business developer
7.3.3 The impact on the decision progress

Investment decision-making can be affected by many different factors and difficulties that can influence the progress and direction of a decision, and which may cause changes in project definitions, aims, and objectives. Internal and external factors that could be controlled by the company (based on its capabilities) can be complex and may have a large negative impact on the success of the investment. Knowing and realizing the benefits of the investment are among the important elements of the progress of an investment decision. The impact of different factors may lead to misunderstanding and poor analysis of the investment’s potential or changes to the benefit rates. Internal and external factors have been encountered and have affected their decision progress in all four companies’ investments. For example, in Company B the delay or non-availability of the raw materials in one of the project stages caused large changes in the expected benefits of the project, which led to changes in the project’s definitions and scope. In addition, the contractor’s delay in responding to the thermoplastic unit’s plans caused an exclusion of the contractors and some of the project’s stages which affected the ROI.

In Companies A and D, difficulties with accurately identifying all of the project implementation requirements during the decision-making process influenced their estimations of the projects’ overall cost, which then affected the realization of the full benefits. Company B faced difficulties, and the factors that troubled them during their planning for the investment decision on the thermoplastic olefins unit affected their estimation of the level of expected benefits. This forced the company to review and investigate some factors to identify the causes of the reduced benefits. Factors such as the cost of the project’s materials and equipment, and the difficulties in scheduling the implementation stages were considered as the reasons behind the reduction in the expected benefits of investment in the thermoplastic unit.

We revisited the factors to identify the causes that reduced the benefits. For example, if it is the cost, we need to come up with something to reduce the cost; if the schedule could be too long, we must change it. We did face these
issues in project A. However, we used a risk-management strategy to manage the cost and schedule in project A, but in the end we had to satisfy the business strategy.

Company B, Project manager

Because of these problems, Company B worked on changing the project definition to achieve and control the required benefits. To do this, the involvement of experts and consultants from inside the company took place before the final review to investigate and analyse possible negative factors and to identify the full benefits. This required more data from an external consultant to identify the benefits and some of the project stages better. The impact of this action increased the planning time for the investment and caused difficulties in reaching the final decision.

Company C faced external factors that affected its petrochemical mining investment, such as the culture; and the country’s economic state was a substantial barrier to the realization of the benefit of the investment. This placed pressure on the company during their decision making. However, it was difficult to realize the benefit of Company C’s petrochemical mining project because of the strength of the Australian currency, which influenced the company’s estimate of the operating cost and the construction cost. This was reflected in the expected benefits of the project.

Company A’s high-density polyethylene project was affected by their poor knowledge of the African regional market, and demand, which was the reason for the low level of the investment’s potential. This issue had an impact on the company’s strategy towards this project, and forced them to consider a long-term strategy instead of a short-term strategy because of high risk and the lack of clarity to forecast the trends of the future market and product demand. However, the company decided to take the risk with no response or action in this investment. The proposed decision for Company A’s hydrocarbon downstream project was not accepted by the company board due to the estimated and forecasted benefits of the investment. The company found that the markets were not
ready for the proposed product, which would seriously affect the ROI. In addition, the financial studies and benefit analyses that were conducted by the consultants were not convincing to the company’s board and its partners because of the high cost of the project; this led to its rejection. This project also affected the company’s future strategy and created a negative attitude to this type of project and how to resolve any associated problems. Company C’s petrochemical mining project suffered a lack of understanding. In addition, the company found that its consultants were not qualified to analyse the investment, the information, and the data from the acquired company; this caused a misunderstanding of the benefits and delayed the project.

In summary, the analysis of the decision-making process, factors and difficulties in each company resulted in a range of issues that could affect the success of the investment decision. Table 7.2 provides a summary of the applied process for benefit realization, the factors and difficulties that affect the investment decision and its impact on the direction of the decision.
### Decision making Process and Criteria

<table>
<thead>
<tr>
<th>Benefit on the investment</th>
<th>Company A</th>
<th>Company B</th>
<th>Company C</th>
<th>Company D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Decision making Process and Criteria</strong></td>
<td>Identifying the benefits based on the raw material availability</td>
<td>Identifying the benefits based on the raw material availability</td>
<td>Investment due diligence</td>
<td>Identifying the benefits based on the raw materials availability</td>
</tr>
<tr>
<td></td>
<td>Opportunities evaluation</td>
<td>The availabilities of infrastructure for the project</td>
<td>External consultants</td>
<td>Forecasting the demand and market</td>
</tr>
<tr>
<td></td>
<td>Traditional financial models</td>
<td>The constructability level</td>
<td>Identifying the benefits based on the technology</td>
<td>NPV and IRR techniques</td>
</tr>
<tr>
<td></td>
<td>Excel sheets</td>
<td>Analysis of the market</td>
<td>Market analysis</td>
<td>Technology evaluations and assessment</td>
</tr>
<tr>
<td></td>
<td>Initial cost estimations</td>
<td>Technology evaluation</td>
<td>NPV and IRR techniques</td>
<td>The availabilities of infrastructure for the project</td>
</tr>
<tr>
<td></td>
<td>ROI return on investment</td>
<td>IRR internal rate of return</td>
<td>Consideration of non-financial benefits</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>ROI return on investment</td>
<td>Identifying the benefits based on the raw materials prices</td>
<td></td>
</tr>
</tbody>
</table>

### Factors and Difficulties

<table>
<thead>
<tr>
<th>Benefit on the investment</th>
<th>Company A</th>
<th>Company B</th>
<th>Company C</th>
<th>Company D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Factors and Difficulties</strong></td>
<td>Lack of experience of some technical aspects</td>
<td>Difficulties in estimating the cost of the project</td>
<td>Lack of accuracy in planning</td>
<td>Difficulties with analyzing the market and demand</td>
</tr>
<tr>
<td></td>
<td>Lack of information of the investment aspects (market, technology performance, implementation cost)</td>
<td>Difficulties in identifying the benefit based on the technology evaluation</td>
<td>The cost of the raw materials and technology</td>
<td>Lack of experience</td>
</tr>
<tr>
<td></td>
<td>Difficulties in measuring the non-financial parameters</td>
<td>Difficulties in assessing the technologies</td>
<td>Difficulties in estimating the final cost of the investment</td>
<td>Time limitations</td>
</tr>
<tr>
<td></td>
<td>Difficulties in analyzing the market trends and demand</td>
<td>The project team capabilities in planning for the investment</td>
<td>Technical issues</td>
<td>Lack of resources</td>
</tr>
<tr>
<td></td>
<td>Difficulties in understanding the product efficacy and technology performance</td>
<td>The utilization plans of the raw materials</td>
<td>Environmental problems</td>
<td>Misunderstanding of the financial figures</td>
</tr>
<tr>
<td></td>
<td>Lack of resources</td>
<td>Difficulties in analyzing the information of the investment aspects</td>
<td>Governmental rules and regulations</td>
<td>Governmental rules and regulations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Forecasting the market</td>
<td>The Market trend</td>
<td>Lack of consultants and consultants performance</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Countries rules and regulations</td>
<td>The economy state</td>
<td>Difficulties in identifying the project requirements affect the cost estimations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Contractors issues</td>
<td>Difficulties in evaluating the operational efficiency</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Time limitation in making the decision</td>
<td>Currency changes</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Consultants performance</td>
<td></td>
</tr>
</tbody>
</table>

### Impact on the decision process and investment

<table>
<thead>
<tr>
<th>Benefit on the investment</th>
<th>Company A</th>
<th>Company B</th>
<th>Company C</th>
<th>Company D</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Impact on the decision process and investment</strong></td>
<td>Increasing on the risks level</td>
<td>Changes on the expectations</td>
<td>Difficulties in identifying the financial benefits</td>
<td>Difficulties in estimating the projects costs which is affected the realization of the benefits</td>
</tr>
<tr>
<td></td>
<td>Unclear vision</td>
<td>Delay on the taking the required decisions</td>
<td>Difficulties in realizing all the benefits</td>
<td>Delay in planning and taking decisions</td>
</tr>
<tr>
<td></td>
<td>Rejection of investment</td>
<td>Exclusion of the project</td>
<td>Delay in making the required decisions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Delay in making decisions</td>
<td>Reduction on the benefits</td>
<td>Re-evaluating some of the planning stages</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Changing the project definitions and specifications</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7.2: The criteria findings, factors of investment benefit realization and their impact on the decision-making process
7.4 Investment justification

To ensure the competitiveness of the investment, justifying it is an essential element of the decision-making process. As described in Chapter 4, justifying the technology and investment is described by many researchers as being very important in understanding the outcomes of an investment and its expected value. The following sections analyse and discuss the justification process with information from the four companies. In addition, the analysis also focuses on the factors and difficulties faced by these companies and how they affected the direction of investment decisions.

7.4.1 The justification process

As has been observed from the case studies, the matter of making convincing justifications for new investments, strategic changes, and technology adoption are important for the companies’ boards and senior management to support their investment decision-making process. Producing the required justification for an investment can be conducted by applying several processes and techniques to appraise the investment from different angles: finance, strategy, and operation. Many techniques and processes are available for this but the issue is how they support the decision makers in achieving an effective investment decision.

In this study, it has been seen that generally companies justify their investments by using traditional investment-justification techniques such as ROI, NPV, and payback, which are used widely to support decision-making processes. Company A has no process called “investment justification” during its decision-making period. However, the justification of an investment can take place during the evaluation of the proposed investment opportunity to see where the possible benefits of the project are. Estimating and identifying the possible financial returns and the level of strategic growth of the investment during this stage are used to convince the company to continue the decision-making process. During this stage, Company A considers that the estimation of the IRR is enough of a signal to justify the investment financially. To produce the IRR, the company
applies very simple tools such as Excel spreadsheets. Such tools are not considered as advanced analysis for this process. Company A intended to conduct all the financial calculations for the investment internally, that is, without using external consultants to justify the investment financially.

For Company C, justifying the investment is part of the feasibility study for an investment. Company C makes use of a number of techniques and processes to justify its investments such as the NPV, the IRR, and sensitivity analysis. Sensitivity analysis is considered an advanced tool to measure the financial aspects of an investment; it is part of the capital-budgeting decision, and can help to show what factors can affect the NPV. It is a valuable technique to measure uncertainty and to forecast the financial trend of the investment. Identification of the financial justification in Company C must be presented and approved by the company’s board and their shareholders. Weakness in the financial justification for the investment could be an issue for the company in obtaining the required funds. Companies B and D also apply traditional techniques to justify their investments, such as the IRR and NPV.

Strategically, no clear processes or techniques are used in most of these companies to produce strategic justifications for the investments. Instead, the identification of the strategic justifications is strongly dependant on the outcomes of three different factors. These are the financial justifications, the market trend, and the companies’ strategic objectives. Based on these three factors, most of the companies intend to see where the strategic benefits and directions lie. In Company B, the strategic justification of the thermoplastic unit and the hydrocarbon project were identified based on the level of alignment of the financial justification and its potential within the company’s long-term investment strategy. The identification of the investment’s strategic justification in Company C was based on their understanding of several issues related to the market, the product’s potential, and the flexibility of the technical aspects of the proposed project.
We justify the investment strategically by understanding the product and how it can be delivered, and how possible it is to ensure the supply of materials to do more expansion, and our understanding of the market.

Company C, Business developer

For the operational aspects of the investment, most of the companies do not apply processes and techniques to identify the operational and analytic justifications internally because of expected difficulties with this task. Companies A and D utilize external consultants to deal with the operational and technical aspects of their investment. The reasons for outsourcing the process of the operational justification are the lack of internal ability and the lack of a technical database. These are considered as sensitive elements that could play a critical role in the investment decision. On the other hand, in Company B the operational justifications are linked strongly to the strategic justifications of their investment. The process of justifying the investment operationally in Company B is based on the technical and operational abilities of the company’s 12 affiliated companies. Understanding the affiliates’ operational abilities must provide justifications about what resources, technologies, and workers can be provided by the affiliates to support a new project. The company adopted this approach not only to support the new projects and investments operationally, but also to improve their strategic justifications by maintaining the affiliates’ growth through increasing their activities, product range, and market share.

It is clear that most of the petrochemical companies are using traditional appraisal techniques extensively to justify investments in new technology and projects. However, traditional financial appraisal techniques encompass the use of payback, NPV or IRR. The use of traditional techniques to appraise petrochemical projects has many limitations and difficulties that could affect project justification and the decision-making process. This is discussed in the next section.
7.4.2 Factors and difficulties affecting the decision process

Many factors and difficulties that could have an impact on the quality of the justification may affect the direction of the investment decision. The level of satisfaction with a proposed project’s financial, strategic, and operational justifications is different across the investigated projects in this study. It was found that a number of the examined projects were not in line with the companies’ long and (or) short-term corporate strategies. This occurred because several factors affected the strategic justifications of the planned investment. Company A had difficulty justifying its hydrocarbon downstream project due to difficulties in forecasting the strategic impact of this investment. The lack of clarity of the project’s strategic impact was affected by several factors, such as the high risk of the project and the shortage of information about market trends.

Company B’s proposed petrochemical project to produce materials for automation was justified effectively as a short-term strategy, but it was difficult for the company to justify it strategically for the long term. The difficulties with identifying the long-term justification occurred because of growth limitations and problems in forecasting the future automation industry trend, which could have an impact on the investment return. Internal issues such as the workers’ abilities and experience played an important role in identifying the investment’s strategic justification. Company C’s marketing department had difficulty identifying the strategic justification for its sodium silicate project. It was difficult for the department to understand marketing factors because of the newness of the proposed product. This was also affected by several other factors, such as the supply chain, customers, and the requirements for entering a new market.

We found that we needed more effort to market this product, and it was difficult for our marketing department to promote this new product in the market; this is also because we need a different supply chain, contacts, and customers, and we are entering a different market.

Company C, Business developer
Financially, most of the companies consider justification as a key element in the investment decision process. Most of the investigated projects within the four companies faced difficulties in producing their required financial justifications. The financial performance of Company B’s thermoplastic unit was not justified due to failure to achieve the targeted IRR for the project. This caused a delay in reaching a decision on the investment because of the need to re-evaluate the investment. Company B’s automation project was difficult to justify financially. The reason behind this was the presence of external factors such as a limitation in the targeted market which was difficult to forecast. Also, the rules and regulations within some countries, such as taxation, affected the estimation of the financial performance of the product, which would in turn have an impact on the ROI. On the other hand, Company B’s petrochemical mining investment was difficult to justify financially because the investment was offered for a 100% capital injection by shareholders. This and the limited time for the decision affected the financial justification and the realization of the benefits of the capital injection.

The level of the financial justification for the automation materials project was good, but it was affected by limitations in the targeted market and by the rules and regulations within some countries which affected the estimation of our financial performance.

Company B, Project manager

In addition to the difficulties of justifying the investment financially, Company B was not satisfied with the financial justification of their sodium silicate plant because of the impact of different factors. These factors related to the project’s cost estimates, marketing of the product, and possible technical issues that could affect the implementation cost of the project, and which could therefore influence the overall financial return. Most of the difficulties that could affect the justifications were related to difficulties in estimating the long-term financial performance of the investment. Company A’s financial justifications for the high-density polyethylene project were more convincing for the short term, with unclear directions of the expected financial performance in the long term; this was
considered a risk to the investment. In Company D, the financial justification for the polypropylene project was difficult to process due to the participation of a government organization in funding the project. For this reason the company was forced to justify the investment’s financial aspects to several parties, such as a consortium of banks, the Saudi Industrial Development Fund, and Public Investment Funds, which caused a delay in making the final decision.

The operational justifications for the investments were also considered an important element of the decision-making process. These were linked to the financial and strategic justifications of the investment and could be affected significantly by financial issues. In Company C, justifying the acquisition of their petrochemical mining investment was not an easy task due to several factors that were difficult to control. For example, the lack of accuracy of technical information and their production capabilities were suggested as problems by company management, and this affected Company C’s operational justification for the investment. Company B’s operational justification for the automation materials project was affected by the expected amount of industrial waste from the proposed operational plan for the plant, which could also be linked to health and safety issues. Furthermore, the complexity of the construction for the project, and the difficulties in finding expert contractors, were critical issues that affected the justification of the project. Company A’s operational justifications for their high-density polyethylene project were not very effective, and were influenced by the performance of the selected technology for the project’s operations. This may have had an impact on their production capabilities and the quality of their product. Also, the non-availability of the required level of skills and workers within the local labour market affected the operational plans and justifications.

*The operational justification of the project was good, but not very effective because of the quality of the chosen technology and the shortage of skilled workers in the region.*

Company A, Marketing manager
The lack of understanding of some external factors was a critical issue that may have affected investment decisions in Companies B and D. Company B’s justification for the automation materials project was affected by several external factors that were difficult to forecast, such as the competition level within the market which had an impact on the strategic and financial benefits of the project. In addition, complexity in forecasting the product price cycles and material price estimates for the long term was critical. Justifying the investment financially and strategically for Company D’s polypropylene project was affected by difficulties in estimating the raw material costs for the long term, which increased the level of the expected risks of the investment.

Although many factors may influence the effectiveness of an investment decision, several internal and external factors contributed to the justification of the investment and the decision-making process and were considered as successful elements of the investment. In Company B, the availability of raw materials for their hydrocarbon plant was the most important factor on which the justification of the project depended. The availability of the required raw material inputs for the project were linked strongly to the improvement in the financial and operational justification of the project, which increased the company’s intention and willingness to invest.

_The main factor that contributed to the justifications was the availability of raw materials like chemical materials and gas. These are the main basis for us to identify and justify the investment; after that, all other factors follow._

Company B, Project manager

The quality and the presentation of the investment justification were also considered important factors for the progress of the decision. According to Company C’s financial vice president, the company’s titanium acquisition was difficult to justify for several reasons, including the large size of the project which could not be managed easily. The company appointed international consultants to support their decision-making process for
the investment. These consultants contributed to the quality and practicality of the information to be presented to the company board to support making the required investment decision. Company C considered the executive, company board, and shareholders’ knowledge and awareness about the industry as contributions to their investment planning. In addition, the applied models and frameworks from the consultants to justify the company’s titanium acquisition played an important role in their acceptance of the overall justification for the investment. Company A’s utilization of consultants’ access to the required funding for the project was the main support for the financial justification and analysis of the investment.

7.4.3 The impact on the decision progress

The company’s satisfaction with the financial justifications for an investment plays an important role in the direction of the investment decision. The justification level can be affected by different issues—internally and externally—that could influence the progress of the decision process. In Company A, the difficulty with effectively justifying the proposed hydrocarbon downstream project strategically and operationally caused a rejection of the project by the company’s board. Strategically, the unreadiness of the market to support the product was the external factor that was difficult to control. In addition, operational difficulties with regard to the technology and designing the proposed product based on precise specifications supported the company board’s decision to reject the investment. Company A’s high-density polyethylene project was difficult to justify financially, which affected their decision-making process. The reason for this was some hidden costs relating to the project’s implementation, which led to incorrect estimates of the project’s financial data. This also influenced the company’s understanding and brought a lack of clarity to the long-term financial and strategic benefits of the project.

Company D’s financial justification of investment for the polypropylene project was made difficult by the involvement of a government organization in funding the project.
This had a negative impact on the progress of planning for the investment by delaying the decision-making process and thus the investment decision. It was difficult for Company C to identify the justification of the sodium silicate project because of internal changes to company management. The changes within the company’s management had a significant impact on planning for the project, and on communication between the planning teams concerning the development and implementation of the project. This issue negatively affected the progress of the investment decision through the company’s lack of the necessary confidence to make a decision for this investment, and thus to achieve their targeted objectives. It was not easy for Company B to justify the thermoplastic olefins unit investment financially because of their difficulty in estimating the cost of the project, which was the main factor that negatively affected the quality of the strategic and operational justifications for the investment. The reason for this was the global economic state in 2007 which increased prices of the raw materials and steel and which delayed them in taking the required decision for the investment. However, it is clear that the justification techniques used in the majority of companies are financially oriented, with less attention given to strategic and operational justification techniques and processes. This shows that most of the companies were focusing more on justifying and understanding the financial issues as their priority to support the decision-making process.

Basically, the investment rate of return is the most important indicator to justify the investment and to make the decision.

Company B, Business developer

As has been mentioned previously, 30% of the companies faced difficulties in justifying their investment strategically. In addition, it has been noted that the strategic justifications are strongly linked to operational issues. These difficulties could be linked to the companies paying less attention to their use of operational and strategic justification techniques to support their decision-making processes. However, the analysis of the justification process findings, factors and difficulties in each company resulted in a range
of issues that may impact the decision direction. Table 7.3 presents a summary of the applied justification process, and the impact of the factors and difficulties on the investment decision.
<table>
<thead>
<tr>
<th>Investment justifications</th>
<th>Company A</th>
<th>Company B</th>
<th>Company C</th>
<th>Company D</th>
</tr>
</thead>
</table>
| **Process and Criteria**  | Opportunities evaluation  
Internal rate of return IRR  
Excel sheets  
Internal financial evaluation  
Utilizing consultants for operational justifications  
Strategic impact  
Intangible benefits | Internal rate of return IRR  
Net present value NPV  
Analysis of the market share  
Strategic criteria for strategic justifications  
The availabilities of raw materials  
The operational capabilities | Internal rate of return IRR  
Net present value NPV  
Product analysis  
Sensitivity analysis  
Data analysis  
Market analysis | Internal rate of return IRR  
Net present value NPV  
Utilizing external consultants for operational and financial justifications |
| **Factors and Difficulties** | Shortage of information of (technology, market)  
Difficulties in analyzing the market  
Difficulties in identifying the long term financial justifications  
Hidden or unseen costs affected the justifications | Difficulties in forecasting the industry and market  
Limitation on the market  
Countries rules and regulations  
Raw material prices  
Construction complexity  
The economy state | Lack of communications between departments  
Difficulties in analysing the market  
Analysing the technical and operations requirements  
Lack of information (technology, market, implementation issues)  
Difficulties in analysing the economical environment  
Countries rules and regulations  
Internal issues (changes on the managements)  
Lack of consultants  
Difficulties in generating funds | Difficulties in estimating the raw material cost in the long term  
Difficulties in obtaining the required funds  
Market trend  
Lack of information’s  
Governmental organizations involvements |
| **Impact on the decision process and investment** | Unconvincing toward the strategic justifications of the investment  
Unclear strategic justifications of the investment performance for the long term  
Unconvincing initial financial justifications  
Less satisfaction toward the operational justifications  
Rejection of the investment | Unclear long term financial justifications  
Unclear long term strategic justifications  
inappropriate financial justifications | Unconvincing justifications  
impact on the financial justifications  
Changing the investment objectives and plans  
Unsatisfying initial financial justifications | Delay in the investment decision making process  
Unsatisfied initial financial justifications  
Exclusion of investments |

Table 7.3: The criteria, findings, factors of investment justification and their impact on the decision-making process
7.5 Technology selection

7.5.1 The selection process and criteria

Planning for the selection of new technology is one of the most challenging tasks for management or for the planning teams within companies. The selection of technology for an investment requires taking into account such issues as the type and quality of the technology, the possible opportunities, and the benefits of the technology. All of these require analysis, understanding, and linking to the companies’ core competencies and capabilities. The process and the consideration for the selection of technology could be different from sector to sector. In the petrochemical sector, the selection of technology for an investment takes into account specific criteria and considerations that must be in line with the petrochemical industry’s development. In this research, all of the companies use different criteria and processes to select the required technology for their investment; each of the companies has priorities during the selection process for the technology.

In Company A, the selection criteria for any required technology are diverse and vary from project to project, based on the project’s definition. However, in Company A the most important criterion for the selection of technology is the availability of the technology within the market or with licensers. Company A considers this matter as a very critical issue for their investment, because it can have an important effect on the cost and price of the technology, which in turn could affect the investment’s overall cost. Consideration of the availability of the technology was also a very important criterion in selecting the required technology for Company A. This was because of their experience in many projects where the technology was not available within the market, and was difficult to buy, due to the licensor’s conditions, and which thus forced the company to consider a partnership with the technology developer. This illustrates the importance and impact of the availability of the required technology on the level of ROI and on the decision-making process.
Company B selects the technology for their investments based on several criteria that operate to avoid possible risks that could affect a project’s success. Unlike Company A, Company B’s most important criterion for technology selection is the history of the technology, which means that the company must select technology that has been approved, certified, and used before in different plants. The aim of this strategy toward selecting the required technology is to avoid possible risks and to understand the actual performance level of the technology as it operates in other plants. This can support the company to reach its decision about the selected technology and its expected return. In addition to this criterion, the company considers the on-site evaluation of the technology as a very important process that must take place. The evaluation process includes visiting other plants using the targeted technology to investigate and understand possible issues and problems that these companies may face operationally. This is intended to support the company in determining the advantages and disadvantages of the technology. Company C uses a different strategy to select the required technology. The company’s strategy towards adopting the technology is strongly linked to their long-term strategic objectives. These are clearly the company’s most important selection criteria: the value and the expected future of the technology.

To select the required technology, we look at the types of technologies and what is the best technology available. The main criterion for the selected technology is that it should be an approved technology; we don’t select a technology that was not used before; we don’t use it for the first time without a reason.

Company B, Project manager

Just as there are key criteria for technology selection, several other criteria played crucial roles in choosing the required technology for the petrochemical projects. The cost of the technology and the providers of licenses are critical issues for Company A’s technology selection process. The cost, and the nature of the provider, are key issues that can help to clarify several other issues, such as the estimation of the production, operational, and
maintenance costs of the technology. Company A also considers the required type of raw material for every technology and how this can affect the costs and objectives of the investment. On the other hand, Company B considers the flexibility, complexity, and simplicity levels of the technology as being important selection criteria. All of these issues are related to the quality and performance of the technology to produce an attractive product, and to increase the company’s competitiveness. Further to the performance of the technology, Company B considers the value added of the technology, and how it can play a role in reducing the operational cost of the project, as the essential parts of technology selection.

For Company C, the selection of the technology is highly dependant on the type of chemical raw materials available. Determining this will contribute to identifying the project’s requirements, especially the specifications of the technology needed. However, based on technology specifications, the company will follow another criterion which is the availability of the technology. Availability is based on a number of different criteria including the availability of expertise and qualified staff to operate and run the technology needed. On the other hand, choosing the required technology in Company A goes through three different stages to reach a successful selection. Starting with assessing what is necessary, several important issues are, for example, the project requirements, including financial data, technical and operational specifications, country regulations, and market research. The second stage is to analyse the outcomes from the first stage to understand the company’s capabilities and potential for using the technology. Finally, and based on the company’s capabilities, the third stage aims to recommend the best technology for the investment by rating different technologies and assessing how each can help to achieve the company’s investment goals.

Company D’s selections of technology for projects are not conducted within the company. The company strategy for selecting the required technologies is by outsourcing the selection process in an attempt to avoid any unforeseen gaps or risks. As was the case in the propane dehydrogenation plant, the company outsourced the technology selection process to professional consultants. The company considers that outsourcing the selection
can give it a better understanding and evaluation of the selected technology and its features and defects, which is then supporting evidence for the decision-making process. However, applying these processes and criteria was affected by many matters that influenced the company’s decision with regard to selecting the required technology and their eventual investment decision.

7.5.2 Factors and difficulties affecting technology selection

Selecting the most appropriate technology for the proposed investment can be affected by several complications, as a number of researchers claim. These can differ from one industry to another, depending on the nature of the industry. In the petrochemical industry, technology selection can be affected by a number of financial, technical, legal, and marketing issues which may influence the effectiveness of the final decision and investment performance. However, in most companies the price and cost of the technology are the main factors that play crucial roles in the direction of the investment decision. The difficulties with allocating the budget to obtain the required technology for the proposed project are mainly linked to the overall financial capabilities of the company. Nevertheless, it has been seen that technology cost issues that arise are linked to many factors such as the cost of implementing the technology, the cost of maintenance, and the costs of operation and production. These factors cause problems for companies trying to decide on the most effective technology for their investment. In Company A, selecting the required technology for the hydrocarbon downstream project was difficult because of their inability to estimate the operational cost of alternative technologies. This issue was critical to the investment decision, as the lack of accurate estimates of the technology’s operating costs could have a direct impact on the overall cost of the project, and thus on the expected ROI. In addition to the operating costs, the maintenance costs of the technology were a serious issue in the investment decision-making process. Company A’s high-density polyethylene project faced difficult challenges in selecting the required technology. These difficulties were caused by the level of complexity of the technology for this project. This complexity made the company wonder about its maintenance costs
and their likely impact on the project. Company B’s petrochemical automation materials project had the same issue.

In addition to the technology’s operational and maintenance costs, the cost of obtaining the required technology can be a critical factor in the investment decision. The cost of the technology can be affected by several factors that may increase its price, such as the exclusivity of the technology which could result in a rethinking of investment feasibility. It was not easy for Company B to obtain the required technology for its petrochemical automation materials project, because of the exclusivity between a limited number of providers and their terms and conditions, which were the reasons underlying the high price of the technology. Licensing the required technology for the projects was one of the main factors that could have an impact on the investment decision. Obtaining the required technology for Company A’s hydrocarbon upstream project was affected by the technology licensor’s obligations and conditions. Conditions such as sharing the expected profit of the project, or owning a percentage of shares on the project itself, were serious issues for the company’s decision-making process, because of their likely impact on the ROI and the project’s expected value added to the company.

We were affected by the licensing conditions to obtain the technology, conditions like being a partner with a percentage in the investment, and this is called ‘loyalty’. Also, the technology licensor sets conditions to share a percentage of the profits and this affects the financial calculations and justification of the investment.

Company A, Business developer

Unavailability of an investment partner with extensive experience to provide the technology was one of the challenges for Company C’s sodium silicate project. The lack of experience within the company in the project field forced them to follow another direction, which was to work in collaboration with more than one engineering consultant to develop the required technology. Although the company sought professionals, they
faced difficulties in planning and evaluating the technology because of their lack of specific consultants in some of the development stages, which increased the project’s timeline. Obtaining the required technology for Company B’s thermoplastic unit was affected by the availability of the technology and the licensor’s terms and conditions. In this project, the single or limited licensor for the technology was a major factor in the search for the way to acquire the necessary technology for the project. Therefore, the licensor’s difficult conditions led to a rethink of the project’s return, which resulted in them making a decision not to proceed with the investment.

Evaluating and assessing the technologies were factors that caused confusion during the process of selecting the required technical solutions for the projects. Company C’s titanium acquisition was a difficult investment for them, specifically with regard to the technology. Understanding the technology’s future and potential were among the company’s main goals to enable them to justify the investment operationally, and to support the investment decision. This required the company to evaluate the technologies in the eight plants carefully. It was difficult to evaluate and assess the capabilities of all of the technologies in the plants for several reasons. The complexity of some technologies and a lack of knowledge were among the main factors that affected the company’s analysis of the value and operational potential of the technology, and which could influence the investment’s expected return. The issue of evaluating the technologies was also a problem for Company C’s petrochemical mining acquisition. Their difficulty in evaluating the technology capabilities affected the company’s plans to estimate the possibilities for reducing their operating costs by integrating their production lines and activities after the acquisition. However, the difficulty with evaluating technologies for the investments may occur because of a lack of expertise and specialists. In Company B, selecting the most appropriate technology for its petrochemical automation materials investment was difficult. The problems were caused by the lack of experts to evaluate the technology and to estimate the expected operational performance before acquiring and implementing the technology.
The lack of experts to evaluate the technology and to analyse the technology’s performance before the purchase was one of the barriers to the selection of the technology.

Company B, Project manager

The difficulties with evaluating the technology for the project proposed are also linked to the specifications and features required of the technology. The technology specifications were among the important factors that could have a significant impact on the performance of a project. In most companies, the impact of the technology specifications can be related to several issues including the maintenance cost, operating cost, the amount of operational waste, the quality of the products, and production capacity. Therefore, determining the specifications of the technology was critical for the selection process for the technology and for the investment decision, because of the possible impact on the ROI. Company B’s petrochemical automation materials project was affected by their difficulty in aligning and understanding the required technology’s technical specifications and their possible impact on operational performance. On the other hand, in Companies A and C, understanding and determining the impact of the technology’s technical specifications on production quality were among the major factors that affected the selection of their technologies. In Company C, increasing the quality of the production in the sodium silicate project was one of the main priorities of the investment. However, it was difficult for the company to control the quality of the product due to multiple providers of the technology and the disparity between the specifications of each technology, which affected their production capacity and quality.

It was important for us to produce the product with particular specifications, and this was difficult because the technology was available from more than one provider, which affected the capacity and the quality of production.

Company C, Business developer
People-related factors are also a major issue that most of the companies in this research study had taken into consideration during the technology selection process. The effectiveness of the technology and its requirements for skilled workers to run the operations were significant parts of the technology’s feasibility and its value to the investment. The technology and the required workforce were critical factors that affected the decision-making process on these investments. In Company A, selecting the technology for the polyethylene high-density project was affected by the requirements from the workforce. The need for a large number of employees and skilled workers to operate the technology and the production lines made Company A question the ability of the technology to meet its investment goals.

From a legal perspective, selecting the necessary technologies may raise issues such as countries’ rules and regulations, or commercial obligations, which could limit the effectiveness and benefits of the technology. In Company B the successful selection of the required technology for an investment was significantly based on the commercially proven value of the technology by global authorities and organizations. This was considered by the company as an imperative element of the operational quality issues and standards of the project. Adopting a commercially proven technology which is dependable on the terms and conditions offered by the technology provider, the government’s regulations, and how these things may affect the project’s operations and financial performance, are important for the company.

Company D’s strategy towards outsourcing the technology selection process resulted in fewer difficulties in evaluating and assessing the required technologies. For the propane dehydrogenation plant the difficulties occurred in building the required joint venture and licensing the necessary technologies; the latter were expected by the company because of the exclusivity of the technology. However, in all four companies the selection process for the technologies and solutions needed for their investment addressed many issues. These included concentration on the most critical problem that could affect the benefits of the investment and the decision direction. The next section aims to show how these
factors affected the selection of the technology and the decision-making process in the four companies.

7.5.3 The impact on the decision progress

Selecting the most appropriate technology is one of the most vital strategic tasks that should be planned with the awareness of all of the aspects and factors that may affect the success of the investment. The nature of technology selection is a complex, multi-criteria problem including many matters which could be in conflict with other aspects of an investment. In this research, most of the four companies’ investment decisions were affected by difficulties in selecting the required technology for their projects.

The difficulties that Company A faced in selecting the technology required for their projects over time led to the company designing a strategy for selection to avoid a possible adverse impact that their technology selection could cause to the progress of an investment decision. The company’s strategy for technology selection is to choose more than one technology for evaluation—economically and operationally—and to measure the benefits and issues that each technology may bring and cause. This strategy increased the company’s readiness for changes in their technology that may have affected their decision-making process and therefore the success of their investment. Company A’s high-density polyethylene project faced changes in the selected technologies which caused an adjustment to their operational plans. The company’s decision to change the licenser of the technology was due to difficulties in the negotiations; this decision resulted in a request for a greater budget allocation to transform the designed operational plans for their second technological option. The second option forced the company into sacrificing the quality of the product and production. Therefore, instead of implementing a high-quality technology with limited production lines, the company decided to implement a mid-quality technology with more production lines. Although this option might increase their production capacity, it had an impact on the quality levels and on the criteria, which could be critical factors affecting the company’s competitiveness.
In Companies B and D, the issue of changing the technology provider also affected the investment decision-making process. The companies were required to search for another technology provider because of a disagreement between the company and the licensor. Therefore, in Company B, in view of the limitation on providers, the company was forced to change part of the project’s definitions, aims, and scope to facilitate the newly selected technology. In addition to the changes in the project plans, changes in the technology required the company to allocate more budget to purchase the technology and its utilities, which resulted in a higher overall cost of investment. As a result, the company decided to stop the decision-making process for a limited time to re-evaluate the company’s capabilities and the project’s feasibility. Company B’s thermoplastic olefins unit faced a similar problem caused by a limitation on the technology provider, which resulted in several difficulties and delays to their progress with the decision. The unsuccessful negotiations with the technology licensors had a negative impact on the decision-making process; this was caused by modifying part of the project’s specifications and details to fit the technology to try to avoid risks and unexpected costs.

*The factors we faced delayed the investment and this was a negative impact on the decision-making process. Secondly, the limited options for technology selection had a serious impact on the decision process by making the negotiations tougher. These factors also forced us to change some of the project definitions and specifications to fit the project’s technology.*

Company B, Project manager

Utilization of financial and engineering consultants contributed a lot to the evaluation and assessment of all applied technology. This occurred within all eight of the acquired plants which supported Company C’s investment decision progress. The company’s strategy to assess the technology focused on tackling important issues such as how this technology affected their operational and production cost, the environment, and production capacity.
In addition, the company board’s knowledge of the technology and the industry helped the company to make a successful evaluation of the technology to support its titanium acquisition. Unlike this investment, selecting the required technology for the sodium silicate project involved several issues that influenced progress with their decision. Issues such as a lack of communication with the consultants and external parties caused a problem in this project and led to changes in the decision. For example, after a while they found that some stages of the planning were not completed and for this reason they had to rework some parts, and these directly affected the cost of investment. However, as has been observed from the case studies, the difficulties in selecting the required technologies and the impact on the decision-making process also resulted from the lack of ability and readiness of the companies to deal with possible adverse factors. Table 7.4 presents a summary of the four companies’ technology selection criteria, factors, difficulties and its impact on the investment decision.
<table>
<thead>
<tr>
<th>Technology selections</th>
<th>Company A</th>
<th>Company B</th>
<th>Company C</th>
<th>Company D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process and Criteria</td>
<td>• The availability of the technology</td>
<td>• Approved technologies</td>
<td>• Assessment of the long term advantage of the technology</td>
<td>• Outsourced technology selection process</td>
</tr>
<tr>
<td></td>
<td>• Technology cost</td>
<td>• No lab technologies</td>
<td>• Selecting the technology based on the raw materials type and availabilities</td>
<td>• Technology price and operations cost</td>
</tr>
<tr>
<td></td>
<td>• The quality of the technology</td>
<td>• The technology must be used before</td>
<td>• The availability of the technology</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Technology assessment and evaluations</td>
<td>• Health and safety assessment</td>
<td>• The company capabilities to ensure the requirements to run the technology</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Operations and maintenance cost of the technology</td>
<td>• Evaluating the flexibility level of the technology</td>
<td>• The quality of productions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Safety of the technology</td>
<td>• Identifying the added value of the technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• The production cost of the technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factors and Difficulties</td>
<td>• Approved technologies</td>
<td>• Licensor terms and conditions</td>
<td>• Difficulties in evaluating the technology</td>
<td>• Finding a professional consultant</td>
</tr>
<tr>
<td></td>
<td>• Single or limited technology provider issues</td>
<td>• The complex of the technology</td>
<td>• Complexity of the technology</td>
<td>• The high cost of the technology</td>
</tr>
<tr>
<td></td>
<td>• The non availability of the technology</td>
<td>• The non availability of the technology</td>
<td>• Difficulties in estimating the operation cost of the technology</td>
<td>• The lack of capability to evaluate the technology internally</td>
</tr>
<tr>
<td></td>
<td>• Difficulties in estimating the operation and maintenance cost</td>
<td>• Difficulties in estimating the operation and maintenance cost of the technology</td>
<td>• Lack of experience</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• The technology cost</td>
<td>• The technology cost</td>
<td>• The shortage of budget</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Difficulties in analyzing the technology specifications</td>
<td>• Difficulties in analyzing the technology specifications</td>
<td>• Lack of information’s about the technology performance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Lack of experts to evaluate the technology</td>
<td>• Lack of experts to evaluate the technology</td>
<td>• Difficulties in building a joint venture</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Lack of specialized consultants</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>• Lack of communications</td>
<td></td>
</tr>
<tr>
<td>Impact on the decision process and investment</td>
<td>• Changing the technology licensor</td>
<td>• Delay in taking the investment decision</td>
<td>• Delay in the decision making process</td>
<td>• Outsourcing the technology selecting process resulted less difficulties in evaluating and assessing the required technologies.</td>
</tr>
<tr>
<td></td>
<td>• Evaluating more technologies which is resulted a delay on the selection decision</td>
<td>• Changing the project definitions to fit the technology</td>
<td>• High cost acquisitions</td>
<td>• Changing technology providers</td>
</tr>
<tr>
<td></td>
<td>• Changes on the benefit and cost estimations</td>
<td>• Changing the technology provider</td>
<td>• Changing consultants</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Allocating more fund to obtain the technology</td>
<td>• Reevaluating the decision making process stages</td>
<td></td>
</tr>
</tbody>
</table>

Table 7.4: The criteria, findings, factors of technology selections and their impact on the decision-making process (see appendix three for terms definitions)
7.6 Investment readiness and abilities

Understanding an organization’s ability to invest is one of the key elements in undertaking successful investments. The concept of investment readiness is based on a number of factors that determine the investment maturity level and the ability to conduct a particular business. These factors include business planning, business modelling, market connection, establishment of management practices, specialist equipment, and the utilization of consultants. In this section, the analysis will focus on several issues that may affect a petrochemical company’s readiness to invest. Issues such as the process of measuring the readiness criteria for arranging new investments are taken into consideration by companies to determine and understand their investment readiness. Also, the analysis will identify possible concerns that may influence the company’s plans to increase their readiness and ability levels, and finally, how their readiness may influence the direction of their investment decision.

7.6.1 The process of measuring investment readiness and company abilities

Determining and understanding investment readiness has been reviewed and discussed by a number of researchers (see section 3.4). However, no academic researcher has developed a model to measure an organization’s readiness in relation to investment. There are several standards and criteria presented by research organizations to determine their readiness level with regard to technology readiness and manufacturing readiness, and these were presented in Chapter 3. With regard to this research, most of the companies have no designed process or a specific criterion with which to identify and measure their readiness and their ability to invest. It has been observed that most of the companies identify their readiness and their ability to invest by determining the company’s financial capabilities. Financial capabilities are considered as a key to solving possible problems with regard to people, technology, and other matters.
As is the case, companies A and D do not apply a particular tool or framework to measure their readiness and ability to invest. They consider understanding their financial capabilities as the key element to making the company ready to carry out the proposed investment. Identifying readiness for the hydrocarbon downstream project in Company A was based on their financial state and capabilities. This was the main component to identifying the company’s readiness and ability in relation to the required infrastructure, technology, process, and people issues. This was also the case in their hydrocarbon upstream project and their high-density polyethylene investment.

We don’t have specific models of a framework to measure the company’s ability to invest; financial capability is the most important thing and it will make available everything we need to start an investment, such as the land, technology, process, people, and new employees for senior positions.

Company A, Business developer

The approach to identifying the companies’ abilities to invest could be different from one project to another depending on project size, specifications, and other issues. Company B had different ways of identifying their ability to run the thermoplastic olefins unit project and the hydrocarbon chemical production project. The company considered the thermoplastic olefins unit as a critical project, because of its aim to introduce a new product to the market, which required increasing the company’s readiness. Based on the project’s definitions, the company realized that its readiness in terms of training the project teams, building the required experience, and ensuring the supply of additional resources were all needed to increase the company’s abilities. On the other hand, Company B’s potential for the petrochemical automation materials project was identified by measuring financial capabilities such as their capacity to obtain the required loans and the budget to implement the project. The respondents claimed that understanding the company’s readiness from their financial capabilities can be done by identifying the company’s credit and financial rating (for example, AAA or AA) which demonstrates their financial ability as rated within the industry.
With regard to non-financial abilities, Company B’s process for measuring their abilities to allocate resources, and to increase competencies and experience for a particular investment, is by allocating an experienced project team to analyse the investment. The project could identify the possible gaps in abilities and the solutions to increase their required readiness for the investment. Measuring and increasing the company’s ability to invest is monitored by a steering committee, which includes members of senior management. The aim of the steering committee is to support the project teams to solve any problems and issues that may affect the company’s ability to implement the projects.

In companies C and D, understanding their company’s ability to invest can also be done by identifying several issues that may play an important role in determining the company’s readiness. Issues such as the performance of the international market, the project time, the market’s readiness to accept the products, and flexibility in receiving the raw materials from the suppliers, are considered as factors on which to measure the company’s ability to deal with external impacts. This can be linked to several internal issues that may affect a company’s ability to undertake new investments. Internal issues such as the size of the projects undertaken and activities, and the availability of engineers and technical resources are considered as signals to identify the company’s abilities and limitations to take on new investments. In addition, the readiness of the shareholders and their interest in investing are among the criteria that the company applies to identify their investment capability.

*We can know our ability to invest from the size of our undertaken projects. Also, we depend on the availability of engineering, technical, and financial resources. It all depends on our strategic plans.*

Company C, Business developer

Most companies consider a number of factors and issues related to the selected investment opportunity to measure their ability to conduct a project. In Company A, the
technical team reports on several issues such as the required infrastructure, project locations, and technical issues; the availability of a workforce is one of the keys to determining the company’s ability to implement a project. The effectiveness of the technical team’s reports was based on their ability to obtain and analyse the related information about technical matters. Company B also takes into consideration technical issues and their impact on the company’s abilities. The company considers their operational and maintenance abilities as important elements to the petrochemical automation materials project. The reason behind considering their operational and maintenance capability as a priority for the company’s readiness and the investment decision is the company’s poor past experience with this type of project.

Managerial readiness was considered an important element of companies’ abilities to invest. In Companies B and D, the efficient leadership of the project and the design of roles and responsibilities to plan for the investment were considered significant issues in their abilities to manage and plan for their investments. This is a critical issue in both companies. However, to increase managerial readiness, most of the companies assign consultants to manage and plan the investment stages. Company C utilized professional consultants such as HSBC as their financial consultants, King and Spalding as legal consultants, and KPMG as accounting consultants to improve the company’s ability. They identified such areas as gaps within the company’s capacity to plan for an investment decision. The next section analyses some possible factors and difficulties that affect companies’ readiness and ability to invest.

7.6.2 Factors and difficulties affecting the ability to invest

The understanding and determination of a company’s ability and readiness toward investment proved to be an essential element of the decision-making process. Measuring and increasing their investment readiness and abilities can be affected by several factors which may influence the successful outcome of an investment decision. Internal and external factors and difficulties were barriers to the companies’ effective planning. Such
barriers are related to technology, management, infrastructure, market, and customers. Technical abilities had a serious impact on the companies’ ability levels which affected their investment decision directions. Most of the companies have faced a number of issues related to measuring and increasing their ability and readiness.

Company A’s abilities were affected by several issues related to technical matters and a lack of information. The company’s ability to plan for the implementation of the hydrocarbon upstream project was affected by several technical barriers and the shortage of skilled labour, which meant that the company was not in a state of readiness and which therefore caused delays in the project’s progress. Company B’s technical ability was also affected by the lack of construction labour, which caused poor construction capacity, as in the case of the company’s thermoplastic olefins unit’s investment. Finding the required number of qualified welders and electricians was difficult. This was linked to the market conditions in 2008–09 which affected the company’s readiness to implement the project.

One of the barriers was the non-availability of construction labourers for project A and most of the projects in 2008 and 2009. For example, the non-availability of qualified welders and electricians was related to their marketability, which affected the company’s overall ability.

Company B, Project manager

Difficulties in market conditions not only played a role in affecting Company B’s ability to allocate the required skilled labour for the thermoplastic olefins unit investment, it also caused difficulties in shipping the required equipment and materials, which therefore affected project implementation. The delay in shipping the required equipment and materials was due to the poor ability of the supplier to ensure on-time delivery; this was seen as a barrier to the project’s performance, which involved a lack of management skill and a poor selection of suppliers. Companies A and D were affected by external factors too, such as a lack of some marketing information which affected the companies’ ability to forecast and analyse the market to support their decision-making processes.
Internal difficulties affected the companies’ abilities and readiness to plan for the required decision in several projects. In Company B, a lack of communication between departments—such as research and development and the project’s management and engineering departments—affected the company’s ability to evaluate the selected technologies for its petrochemical automation material project. This issue was also the reason behind the difficulties in the process of selecting the required technology, which caused a delay in the project. As there was a lack of internal communication between the company’s departments, the issue of external communication between the company and the technology licensor affected their ability to obtain the required technology. This occurred in Company B’s thermoplastic olefins unit investment, where the company found that differences in understanding the design bases between the licensors, the project team and the project owners were serious issues caused by their poor communication and poor technological readiness.

Difficulty with allocating the required workforce was a barrier for several companies and affected their ability to plan for an effective implementation of projects in Companies C and D. In Company C, allocating the required workers for the titanium acquisition faced a number of objections from the company’s management. This resulted from the management’s concerns about the company’s ability to finance and manage the required extensions to the acquisition. However, as the respondent claimed, the company’s financial capabilities at the time of their titanium acquisitions were barriers because of the company’s commitments toward other projects and investments. In addition, the company’s aim to obtain the required funds from banks and other organizations for the titanium acquisitions was a difficulty that had an impact on their financial readiness and their decision-making process.

*We were not able to deal with several managerial issues within the acquired plants because of the different cultures, countries, remote locations, different tax environments, and environmental issues. Many things affected us in taking up the investment.*

Company C, Senior Vice President Finance
In addition to Company C’s titanium acquisition, they faced several factors that affected their ability to plan for managing the acquisition of the eight plants effectively. Issues such as the differences in culture, locations of the plants, the different tax environments, and environmental issues were difficult to manage because of the small size of Company C and its poor managerial readiness to manage and control all of the plants. The next section analyses and discusses the impact factors that may affect the companies’ readiness in their decision processes.

7.6.3 The impact on the decision progress

As the previous section illustrates, the ability to make a successful investment decision can be influenced by many factors that may result in less effective and less accurate decisions; most of them play a critical role in affecting the directions of the decision-making process, as has been observed from the case studies. Most companies in the research case studies were influenced by several internal and external factors that caused a number of actions such as rethinking their decision, changing part of their investment objectives, and delay in making the required decisions and plans. For example, in Company B, differences in understanding the design basis of the thermoplastic olefins project between the technology licensors, the project team, and project owners was an issue that resulted in rethinking the project specifications and its requirements; this also delayed the decision progress in the planning stages. The shortage of contractors and technological experts caused a delay in the execution of some of the project’s activities. The respondent claimed that a further negative contribution to the decision process was the extent of ongoing activities and projects simultaneously, which affected the company’s performance in making the required plans and decisions on time.

In Company A, the issues that affected their ability to plan for the hydrocarbon upstream project caused an increase in project cost. For this reason, the company was forced to review some of the project’s phases and requirements to recalculate and manage the cost
of the project. However, the company’s high-density polyethylene project was also influenced by external factors, such as the contractor’s performance and ability to implement the project effectively. This had a significant impact on the decision-making process; the company was forced to apply changes to the contract agreements, and to change contractors and project specifications to facilitate the project. Difficulty in estimating the required workforce was a critical issue for companies, and one which affected their ability to implement their projects successfully. In Company C, ensuring the supply of the required workers for the titanium acquisition was a difficult task due to a number of interventions from the company’s management. Interventions occurred because of the management’s concerns about the company’s ability to finance and manage the required extensions to their acquisition. For this reason, the company decided to put on hold some other investments, which also resulted in their limited ability to take on more investments.

The difficulty with managing and increasing the company’s readiness to deal with their possible problems was also caused by managerial issues that affected the decision-making process. In Company B, dealing with petrochemical automation materials was a difficulty they faced in managing and planning for the investment decision. The company’s senior management realized that their management unreadiness had led to changes to a number of elements of the project. Changes in the project team members and leadership occurred to improve planning for the required decisions. These were followed by a decision to change a number of other significant aspects of the project, such as the technology provider, contractors, and consultants. This also had a great impact on delaying the project’s stages and increasing the overall cost of the project.

The gap in our planning ability was solved by making changes in the project team members and leaders. A decision to change the technology provider, contractors, and consultants was made.

Company B, Project manager
In Company C, a lack of readiness and an inability to plan for the investment decision for the company’s petrochemical mining project were among the critical issues that influenced their effectiveness in taking decisions. The respondent claimed that their low utilization of consultants resulted in a poor ability to understand and analyse the information about the targeted company they intended to acquire.

*In the petrochemical mining project, our understanding of the mining was not like our understanding of the TIO2; our understanding of the mining was weak, and because of that we did not get the targeted return from the project. Also, because of this, we changed the management of the project three times.*

Company C, Senior Vice President Finance

This resulted in delays in taking the required decisions for the investment, which increased the complexity to plan for a number of stages. Managerial readiness was a critical issue in Company C. Their sodium silicate project was faced with several managerial barriers that caused a delay in the project’s stages. This was a result of the management’s bureaucratic approach toward processing some of the project requests, and management’s inflexibility towards technological and economic feasibility. Company D’s propane dehydrogenation investment was affected by the poor support and involvement of some of the company’s members. This caused a delay and lack of vision during the decision-making process. Several actions were taken by these companies to resolve the issues they faced to ensure successful investment decisions.

### 7.6.4 Alignment actions

Aligning their investment decision with corporate strategy is a significant element to the success of an investment. Creating the desired alignment required effective treatment and actions taken towards the possible problems that may affect achieving the business
strategy and its objectives. As has been observed from the first study, most of the companies had no clear strategic model to ensure alignment and to increase their readiness to support achieving the business strategy and the objectives of their investments. This demonstrated a number of gaps in planning to take the required actions to resolve the outstanding issues.

As an effective system to ensure the required alignment and ability to make the investment decision, Company B was the only company that applied a system to increase the company’s ability to reach an alignment. The difficulties that Company B faced in planning for the investment decision were handled by applying a “recovery system” which was intended to maintain the project benefits by resolving the issues to achieve their business strategy and their investment objectives. The recovery plan aimed to manage and control the issues that may have affected the investment decision’s success, such as possible increases in the project’s cost due to internal and external factors. In companies A, C, and D different strategies were applied to ensure effective solutions for their expected and unexpected problems. In Company C, increasing the company’s readiness and ability to deal with expected difficulties and factors was based on utilizing consultants, and the company’s ability to generate the required funds through shareholders. This strategy wasn’t very effective in some stages of Company C’s projects, which forced the company to take other directions.

**People issues**

Most of the companies had a clear strategy toward solving their problems and the issues related to people. The impact of people issues on the success of the investment decision was recognized clearly by most of the companies’ management teams. Methods of dealing with people issues are similar in most of the companies. In Company A, issues related to people or technical matters can be resolved through an established department of the company called Project Management Controller (PMC). The aim of this department is to transfer and utilize the experience of its people and technical issues from
their previous projects to support the investment decisions for new projects. In Company B, most of the people issues were related to training. The company’s strategy towards people issues included the design of a special programme, depending on the nature of each investment. This programme contains a number of solutions to resolve possible issues that relate to people. Solutions such as training, staff rotation, and acquiring external skills were considered during the decision-making process of Company B’s investments.

In Company C, the impact of people issues on their titanium acquisition forced the company’s board to conduct weekly steering committee meetings to discuss the people issues in their eight plants. Company C was aiming to implement its philosophy and style, which was difficult because of the differences in culture and the geographic distances between these plants. As a result, and to create the required alignment, the company strategists worked on visiting all of the sites to improve their communications by conducting a meeting with all of the senior management of these plants to explain the company’s philosophy, vision, and how to reflect this through the people within the company. In Company D, the board’s strategic decision to increase the Saudi percentage in its propane dehydrogenation project to obtain the necessary governmental support resulted in a planning difficulty in the allocation of skills, which caused a disagreement and conflicts between senior management, the company board and their partners.

**Technical and operational issues**

In most companies, assessing the possible technical and operational factors that relate to technology is considered one of the essential elements for the success of an investment decision. However, as was observed from the case studies, it is difficult to assess a possible technical issue because of the complexities of technologies and their operations. Several issues were faced by the four companies internally and externally and these influenced the success of their investments. For example, contractors’ delays were a critical issue for Company A’s hydrocarbon downstream investment, which affected the
start of the project’s implementation. In addition, the contractors’ rejection of conducting a particular stage of the plan implementation was a critical issue to the project’s progress. The company’s action to resolve this issue was to change the contractor, which resulted in a delay in the project timeline and increases in implementation costs. In addition, the contracted workers’ poor qualifications caused a problem; this led to problems with safety and the cost of the project. As a result, the respondent claimed that these factors resulted in difficulties in running and operating the plants. This was an issue in many projects in the company. As was the case in the company’s high-density polyethylene project, their action to resolve the operational problems was to allocate expert teams with the appropriate experience and background. This resulted in changes in their operational and production plans to increase the efficiency of the plants. This issue raised the company’s concerns about the selection criteria for the contractors and unease about their qualifications.

In companies B and C, understanding the possible technical and operational issues that related to technology during the decision-making process were very significant to the progress of their plans and decisions. Discovering early the issues related to operating the technology is very important, indeed before the implementation stages begin. The strategies of Companies B and C to discover and resolve their possible problems were by utilizing experts or specialized consultant companies to determine the level of complexity and possible solutions. The companies considered outsourcing technical and operational problems to ensure the efficiency of their projects, which was also the case in Company D’s technology selection process.

*Organizational issues*

In most companies, organizational issues are considered as the major factors that affect a company’s ability to ensure their required alignments. From the case studies it has been observed that organizational issues related to management, project teams, roles, and responsibilities were affected by the companies’ readiness and progress in their
investment decisions. In Company A, the poor selection of the project team and leaders for the hydrocarbon upstream investment was a critical issue that influenced the company’s ability to plan the project’s stages. In addition, Company A’s strategy towards the given level of authority of the project leader was considered a critical gap in some projects, because of the lack of involvement from senior management in approving the plans and taking the required decisions. At the same time, giving the project leader a high level of authority was seen by the company as a strategy to ensure flexibility and a faster decision-making process.

The large number of ongoing projects in Company B caused an organizational issue by affecting the formation of the most appropriate team for the projects. Changes within the project teams due to promotion, rotation, and lack of experience caused confusion and difficulties in tracking the project’s stages between teams. Changes within the project teams resulted in confusion in defining people’s roles and responsibilities, which caused delays and ineffectiveness in some projects. In Company C, the titanium acquisitions were affected by the organizational structure and the applied business process within the eight plants. This forced the company to re-evaluate the structures, the applied business processes, and the management styles, to see their possible impact on the financial returns of the investment. The re-evaluation resulted in the streamlining of the authority of senior management and their roles and responsibilities to ensure a more effective structure and business process. Poor communication between the eight plants because of the geographic distances was a critical issue that affected the company’s decision-making process towards possible risks. Company C’s action towards poor communication between the plants was to change the organizational structure and implement a shared communication system between the eight plants to increase the efficiency of the business process.

Company C’s sodium silicate project and Company D’s propane dehydrogenation project were faced with several organizational issues, such as the poor performance of the project teams and their managers, which resulted in changes to the projects’ management to improve communications during planning. The changes in project management in
Companies C and D had a positive and a negative impact on their decision progress. Negatively, changes in a project’s management resulted in difficulties for the new project team to track the planning for the investment, which caused a delay to the decision-making process. However, on the positive side, changes to a project’s management resulted in more effective planning of the investment decision.

7.7 Summary

In conclusion, this chapter has presented a cross-case analysis of the case studies of four petrochemical companies’ decision-making processes in order to achieve the research objectives, questions and answers. Many factors and difficulties have been identified that could have a negative impact on the decision-making progress and decision-makers’ performance. These factors and difficulties are categorized in relation to five different elements critical to the technology investment decision process, which are: investment justifications; technology selection; investment readiness; alignment; and benefit realization, all of which have proved to be significant to the investment decision.

The investigation has shown that the five elements have a significant effect on the success of the investment decision, which is confirmed in the findings and the cross-case analysis. It was seen that the factors and difficulties that are faced during the investment decision-making process are vastly different in all four companies. However, the companies all share some common characteristics with respect to the technology selection process and criteria. It was found that the companies’ abilities to identify the benefits of the investment are affected by internal and external factors related to their abilities to manage the benefits and external factors that are difficult to control, such as the market. In addition, the four companies’ strategies to justify the investment financially, strategically and operationally are different. Most of the companies rely on justifying the investment financially rather than focusing on the strategic and operational aspects, which has an impact on the investment decision progress. Justifying the investment is also affected by internal and external factors, and issues that are
manageable and unmanageable, such as difficulties in forecasting market and economic trends, which are considered to be critical issues in petrochemical investments. Moreover, decision makers and planners within most of the companies seem to either be unaware of the importance of readiness for investments, or they face difficulties in dealing with the factors and issues raised during the decision-making process due to the lack of readiness measurement tools. Therefore, the lack of strategic vision and effective, documented decision-making processes not only limits the effectiveness of the investment planning, but also affects the companies’ aims to achieve competitiveness and growth. The limitations and conclusions of the findings will be discussed in the next chapter.
Chapter Eight

Discussion and recommendations
Chapter Eight
Discussion and recommendations

8.1 Introduction

This research aimed to investigate the issues that Saudi petrochemical companies face with regard to their investment decision-making processes. The study focused on investigating the decision-making criteria and processes in petrochemical companies, identifying gaps in the processes by investigating the factors and difficulties that affect the success of the investment decision. In addition, by taking into account the context and related literature, a clearer picture was gained with regard to the decision-making practices in petrochemical investment.

8.2 Summary of the research conducted

The research approach was to investigate several elements that are critically involved in planning for investment decisions, in order to understand the issues influencing the investment decision-making processes applied by Saudi petrochemical companies. The research started by exploring the relevant literatures to investment decision making process in manufacturing industry.

The literature review revealed a lack of empirical research into the technology investment decision-making process within petrochemical companies. An investigation of the factors that could affect such processes was conducted by reviewing the related literature. The outcomes of the literature review were used to design the questions for a preliminary data-collection stage. The preliminary data-collection was reflected in conducting a first study focused in interviewing petrochemical company’s decision makers. This was
followed by an analysis of the preliminary data collected from the first study, which helped to identify factors, issues and difficulties affect technology investment decision making process within Saudi petrochemical companies. The analysis and outcomes of the first study were played an important role in the second study by define the case study interview content for the subsequent data-collection stage at four petrochemical companies in Saudi Arabia. The second study were aimed to investigated in-depth the findings from the first study and the factors and difficulties impact technology investment decision by interviewing people who been involved critically in planning for investment decision.

For this research, the data was collected through applying semi-structured interviews with people who were central in making investment decisions, such as CEOs, executives, managers, including finance managers, business developers, and project managers. The analysis of the collected data was conducted individually and comparatively, and was presented and discussed to identify the factors and difficulties that lie behind the complexity of technology investment decision-making processes in the Saudi petrochemical industry.

8.3 The key research findings and discussion

This section explains and analyzes the study's findings in relation to the research aims and objectives.

*Objective one: Identify the internal and external factors and difficulties that influence technology investment decision-making and evaluation practices in petrochemical companies.*

To address the first objective, factors affecting the investment-decision process were identified through an in-depth review of the related literature on the general decision-making process in the manufacturing industry. Internal and external factors were
identified and discussed in Chapter 3. Studying and reviewing the factors and difficulties that affect the decision-making process from the literature informed the design of the questionnaire for the first study; these factors and difficulties are summarized in Table 3.1. However, new factors and difficulties that particularly affect the investment decision-making process in the Saudi petrochemical industry were identified through a preliminary investigation of the processes of four companies; these are presented in Chapters 6 (see tables 6.2, 6.3, 6.4, 6.5) and Chapter 7 (see tables 7.2, 7.3, 7.4).

Analysis of the factors was conducted through an individual analysis of the investment decision-making process and its elements in each company. The factors and difficulties were categorized and classified into five different elements involved in the decision-making process: investment justification, technology selection, company readiness, alignment, and benefit realization. The analysis of these factors also compared the similarities, differences, and impact of the factors and difficulties on the progress of the investment decision-making process.

The cross-case analysis of the four companies identified the most critical and less critical factors and difficulties. In terms of justifying the investment, factors such as a lack of information and the difficulties in analyzing and forecasting the market were considered as critically important factors that may influence the investment decision. Licensing the required technology and the difficulties in evaluating and assessing the technology were also considered very important factors that affected both justifying the investment and selecting the necessary technology. Most of the companies had difficulty in understanding and realizing the investment benefits for several reasons, these include difficulties in estimating the project costs and in forecasting the economy and market trend. These critical factors may cause rejection or exclusion of the investment.

As factors affecting the investment decision-making process are presented in the literature, the research also contributed by exploring specific findings related to the petrochemical industry, which influence the technology investment decision-making process. Table (8.1) provides a summary comparison between the reviewed literature and
the research findings of factors affecting investment decision-making in the petrochemical industry. New factors were found to be affecting the petrochemical companies’ investments. With regard to justifying the investment, companies face difficulties in creating an early understanding of the impact of technology operation costs on the total cost of the investment. Factors were also found with regard to readiness, such as the ability to plan and utilize the technology, which is also influenced by the technology selected. With regard to realizing the expected benefits, petrochemical companies were found to experience difficulties in analyzing the benefits of the investment, due to several internal and external factors such as the companies’ capabilities, forecasting the market and technology performance.

### Summary of factors affecting investment decision-making in the literature review

<table>
<thead>
<tr>
<th>Organization’s capability</th>
<th>Management issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competition</td>
<td>Poor strategies</td>
</tr>
<tr>
<td>Lack of skills</td>
<td>Lack of information</td>
</tr>
<tr>
<td>Lack of resources</td>
<td>Planning for production</td>
</tr>
<tr>
<td>Availability of technology</td>
<td>Realizing the benefits</td>
</tr>
<tr>
<td>Size of the firm</td>
<td>Align technology with the organization</td>
</tr>
</tbody>
</table>

### Summary of factors affecting investment decision-making in the petrochemical industry

<table>
<thead>
<tr>
<th>Technology cost and conditions</th>
<th>Analyzing the quality of the technology and its impact on product quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimating technology operation cost</td>
<td>Ensuring the investment requirements</td>
</tr>
<tr>
<td>Poor understanding of technological issues</td>
<td>Ensuring the required resources for the selected technology</td>
</tr>
<tr>
<td>Poor forecasting of market to justify the investment</td>
<td>Difficulties in forecasting the market</td>
</tr>
<tr>
<td>Difficulties in analyzing information</td>
<td>Complexity with planning for marketing the products</td>
</tr>
<tr>
<td>Difficulties in estimating project’s requirements</td>
<td>Difficulties in increasing people readiness</td>
</tr>
<tr>
<td>Difficulties in building joint venture</td>
<td>Lack of project leaders</td>
</tr>
<tr>
<td>Technology licensing and achieving agreements with technology owner</td>
<td>Lack of communications between people involved</td>
</tr>
<tr>
<td>Complexity in evaluating the technology</td>
<td>Health and safety issues</td>
</tr>
<tr>
<td>Planning to operate the technology</td>
<td>Estimating technical issues during decision making</td>
</tr>
<tr>
<td>The non-availability of the technology or single owner</td>
<td>Lack of expert consultants</td>
</tr>
<tr>
<td>Lack of information regarding the technology</td>
<td>Contractors issues and agreements</td>
</tr>
<tr>
<td></td>
<td>Difficulties in estimating the total cost of the investment</td>
</tr>
<tr>
<td></td>
<td>Lack of readiness to utilize the technology</td>
</tr>
<tr>
<td></td>
<td>Lack of experience and knowledge toward the project type</td>
</tr>
<tr>
<td></td>
<td>Government rules and regulations toward projects and technologies</td>
</tr>
<tr>
<td></td>
<td>Poor company board knowledge</td>
</tr>
<tr>
<td></td>
<td>Controlling the investment cost</td>
</tr>
<tr>
<td></td>
<td>Creating an appropriate alignment plan</td>
</tr>
<tr>
<td></td>
<td>Difficulties in identifying the benefit and risks in the early stage</td>
</tr>
<tr>
<td></td>
<td>Identifying the expected benefit based on the technology type</td>
</tr>
<tr>
<td></td>
<td>Difficulty with understanding factors (ex. market share, financial options)</td>
</tr>
<tr>
<td></td>
<td>Difficulties in justifying the investment</td>
</tr>
<tr>
<td></td>
<td>The techniques applied to justify the investment</td>
</tr>
<tr>
<td></td>
<td>Difficulties in aligning the investment with the strategic objectives</td>
</tr>
<tr>
<td></td>
<td>Lack of documented decision-making process</td>
</tr>
</tbody>
</table>

Table 8.1: Summary of factors affecting the investment decision making process
Objective two: Understand how petrochemical companies measure the level of readiness to invest in new technology and what factors/difficulties affect the companies’ ability to invest.

It is evident from the analysis of the case studies that the companies’ ability and readiness were key elements in the decision-making process and the success of the investment decision (see 6.3.3.3 and 7.6). Decision makers within the four petrochemical companies believed that there was a gap in understanding the impact of their company’s abilities and readiness for the planning stage of their decisions. As Zaheer, (1995) point out that the limited readiness of the organization along with lack of confidence could affect negatively the decision making process. In this research critical factors related to the organization readiness leading to less effective investment decisions include: poor business planning; poor establishment of investment management practices; lack of management support; and issues related to people readiness. These were considered matters that could affect a company’s ability to implement the investment successfully. These factors are summarized in Table 6.4 in Chapter 6 of this thesis.

Externally, the decision-making process was influenced by a lack of readiness in relation to a number of identified factors, including a lack of specialized technologies, poor utilization of consultants, difficulties in forecasting the market, and lack of financial capabilities. These issues affected the petrochemical companies’ overall abilities and readiness to achieve effective decision-making. Analysis of these factors and difficulties demonstrated that all four companies’ investment decisions were negatively affected, causing delays in the decision process, execution of the projects, changes to the projects’ definitions and specifications, and other factors that resulted in less successful investment decisions.

In addition, it was observed that three of the four companies have no documented or applied process to measure their readiness and abilities for technology investment, and petrochemical investment in general. This may be considered a critical gap for these companies. The process and criteria that companies follow in order to understand their
readiness to make new investment contain differences and similarities. For example, three companies consider financial readiness and capability as the main criteria to determine the company’s ability to ensure the investment requirements. On the other hand, the availability of resources such as chemical materials are also considered a priority that plays an important role in making the investment decision. Several researchers were claimed that the availability of resources and funding as a crucial issue in making the required decisions (Berry et al., 2001; Harenstam et al., 2006 Christensen; 2007; Wagner and Hansen, 2005). It was observed from the analysis that both issues are linked together and the understanding of both issues can be critical to the investment-decision process.

External issues were also found to affect the companies’ abilities to invest; for example, forecasting and understanding the market were considered barriers to all the companies’ investment decisions. In addition, difficulties in communicating with partners and suppliers were also considered issues that affected the companies’ readiness during the initial investment planning. On the other hand, internal issues were found to be critical factors in the readiness to invest, such as people’s readiness for the technology. Difficulties in ensuring the skills and technical manpower were considered major challenges by petrochemical companies, and caused further difficulties in making the investment decision. A number of academic researchers (Axtell et al., 2001; Fillis et al., 2004; Baldwin et al., 1996; Warren, 2004) considered people skills and readiness as an essential elements in the organization decisions. This issue was also linked with technology readiness and the companies’ ability to evaluate and understand the technology before making the investment decision. The company’s ability to understand the type of technology and its expected implementation issues was a critical factor that could affect the companies’ plans toward the selection and utilization of the technology. This was also affected other aspects of the investment decision-making process, such as the return on the investment.
**Objective three:** Examine the investment justification approach that companies are using and investigate the factors that may affect justifying the technology investment decision in petrochemical companies in Saudi Arabia.

As was observed from the case studies, the matter of providing convincing justifications for new investment, strategic changes, and technology adoption are very important to the companies’ boards and senior management (see 6.3.3.1 and 7.4). Literature has also identified the importance of investment justification in technology decision making (Kodali and Sangwan, 2004; Small, 2006; Krar, 2000). In this study it was seen that three of the investigated companies justified their investments by using traditional techniques such as NPV and IRR, and this affected the quality of the justifications they produced. In addition, it is shown in the analyses of the case studies that most of the companies do not use, for example, advanced software to justify and appraise their investments.

Three of the companies investigated focus more on justifying their investment financially and identifying the benefits, with less attention given to strategic or operational matters; this affects the quality of their justifications and their investment decision-making processes. Internal and external factors and difficulties were identified such as forecasting the strategic impact (long or short-term), poor risk identification, difficulties in forecasting market trends, lack of information about technology and the market, lack of understanding governments’ rules and regulations, and difficulties in understanding the technologies’ performances, all factors which led to difficulties in producing convincing justifications. Canada and Sullivan, (1989) has also considered the organization capabilities in analyzing the related factors such as the market and possible risks as a significant issue in justifying technology investment.

The levels of satisfaction with the financial, strategic, and operational justifications of the investigated projects in this study varied. It was observed from the analysis that a number of the investigated projects were not in line with the companies’ long and short-term corporate strategies. Gunasekaran et al., (2001) has identified the top management satisfaction level with regard to the produced justifications as an important issue to the
success of the decision making process. On the other hand, most of the investigated projects within the four companies encountered difficulties in producing the required financial justification. The analysis of the case studies demonstrated the impact of these factors and difficulties on the investment decision-making process, which could result in companies delaying the investment decisions.

**Objective four: Investigate the technology selection methods and criteria that the petrochemical companies follow and how/what factors can impact the investment decision.**

As was observed in the case study analyses, planning for the selection of new technology for petrochemical projects is one of the most critical tasks for the projects’ management and planning teams within the four petrochemical companies (see 6.3.3.2 and 7.5). Lamb and Gregory (1997) considered the planning for the selection of the required technology as one of the important stages in the decision making process. In all four companies, the technology selection process for an investment took into consideration a number of criteria, issues and factors that may influence the success of the selection process. However, all four companies have different criteria, priorities, and processes to select the required technology for their investment; these are based on each company’s strategy and management style. In addition, the nature of the product also plays a significant role in the process of selecting the technology needed.

Yap and Souder (1993) claimed that the technology selection can be affected by several internal and external factors which are may lead to a failure in selecting the required technology. However, it is apparent that the four petrochemical companies’ technology selection processes are affected by a number of financial, technical, legal, and marketing issues which may influence the effectiveness of the final decision and a company’s investment performance (see Table 7.4). Financially, the cost of the technology was a critical factor that played a role in the direction of the investment decision through influencing the expected return on investment (ROI). Most of the companies faced
difficulties in allocating the necessary budgets to obtain the required technology for their proposed projects; this was closely linked to the financial capabilities of the companies. Nevertheless, it was found that the technology cost issue is linked to many factors, such as the costs of implementation, maintenance, operation, and production. All of these factors caused difficulty in justifying the technology financially, which affected the selection and decision-making processes.

Difficulties in assessing and evaluating the technology sometimes confused the decision makers in estimating the expected performance and operation of the technology. This negatively affected the decision-making process. Several issues were found to be significant in the selection and obtaining of technologies; issues such as licensing the technologies and the licensers’ terms and conditions had a negative influence on the financial plans of the investment, the operation and production, and the ROI. Table 8.2 shows important factors related to technology selection which were identified from the conducted interviews. More detailed information’s can be found in Table 7.4 and section 7.5 which include descriptions of the factors and difficulties that affect the technology selection process.

<table>
<thead>
<tr>
<th>Factors identified from studies one and two</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Licensor’s terms and conditions</td>
</tr>
<tr>
<td>• Limited availability of the technology and suppliers</td>
</tr>
<tr>
<td>• The cost of the technology</td>
</tr>
<tr>
<td>• The complexity of the technology</td>
</tr>
<tr>
<td>• Difficulties in estimating the operation and maintenance cost of the technology</td>
</tr>
<tr>
<td>• Lack of specialized consultants</td>
</tr>
<tr>
<td>• Lack of information about the technology’s performance</td>
</tr>
<tr>
<td>• The lack of capability to evaluate the technology internally</td>
</tr>
</tbody>
</table>

Table 8.2: Important factors related to technology selection identified from the analysis
Objective Five: Examine the applied alignment actions within the petrochemical companies and how they can impact the investment decision.

Creating the required alignment for technology investments within the four companies is a process that varies from one company to another. Teo and King (1996) reported that alignment between the technology and the business is a key issue in ensuring the success of technology adoption. The meaning of alignment in this research is the way in which petrochemical companies deal with the issues, factors and difficulties by taking the required actions to achieve successful investment (see 6.3.3.4 and 7.6.4). The research has investigated the importance of ensuring the required alignment and how it could affect their decision-making process. As observed from the analyses of the case studies, only one company of the four applied a formal method to deal with difficulties that may have influenced the success of their investment. The other three companies had no strategy or method to solve possible issues that they may have faced during planning for the investment decision. Issues related to people, management, organization, techniques and technology occurred at different stages during the investment decision-making process.

Objective Six: Identify the factors and difficulties which impact identifying benefits for technology investment.

In all companies, estimating the investment benefit was conducted through a process. In three companies, the applied techniques for estimation of benefits are based on several elements such as calculating the cost of raw materials, the cost and availability of infrastructure, the expected price for the product, and the expected operating rates of the plant. The effectiveness of these financial models is also based on market analysis and customers’ demand.

Measuring the benefits particularly from technology investment is complex and difficult stage of the decision making process (Seddon et al., 2002). However, realizing the
expected benefit from an investment in the four companies is a critical issue for several reasons (see 6.3.3.5 and 7.3). In the case of petrochemical projects, the most important factor is a company’s capability in obtaining and allocating the required chemical raw materials, which is considered a critical factor to the progress of investment. As Truax (1997) claimed that the diverse nature of the project are one of the barrier to the realization of the investment benefits. In addition, realizing the benefit of the investment within the four companies was based on the companies’ capacities to build the project, the level of project complexity, and its impact on the implementation and overall costs, and on the ROI.

Factors related to finance, technical, and management matters were faced in all four companies before and during their planning for the investment. Important factors such as difficulties with forecasting the market trend, lack of information, and difficulties with understanding the efficiency of the technology and how it can reflect in the ROI, were considered as being among the issues critical to the realization of the benefits. However, most of these factors had a wide impact on planning for the investment decision, for example changes in projects’ definitions, specifications and targeted goals. Section 7.3 and Table 7.2 provide more detailed information and analysis of the factors that affect realizing the benefits of the investment.

**Objective seven: Proposing a framework for technology investment decision making to support decision makers in achieving successful investment in the Saudi petrochemical industry.**

In this research study, the framework for successful technology investment decision-making in the petrochemical industry is based on important variables that were designed with the aim of supporting Saudi petrochemical companies to achieve more successful investments in order to gain competitiveness. The framework takes into account several important elements that are critical to the investments in technology: factors such as management, the decision-making process, the firm’s abilities, resources, internal and external factors, strategies and technological factors.
However, due to the need for and the lack of frameworks that were appropriate to the petrochemical industry generally and the Saudi petrochemical industry specifically, it was necessary to design a framework for successful technology investment decision-making that took into account the trends and environments of the Saudi petrochemical companies. To address the research questions and objectives, the research framework aims to improve the technology investment decision making by focusing on five different elements:

- Investment justification
- Technology selection
- Company readiness
- Technology alignment
- Benefit realization
Identify the investment opportunity and its requirements

Identify the investment opportunity financial, strategic and operational justifications

Does the identified justification produce convincing reasons to invest, satisfying potentials and benefits?

Yes

No further analysis required. Evaluate another investment opportunity

No

Yes

Identify the project specifications, requirements and select the required technology for the investment

Does the selected technology fit the project requirements? Does the technology fit the strategic objectives of the investment?

Yes

Identify the company people, financial, manufacturing, management and environment readiness level toward the investment and the selected technology

No

Are the identified readiness level, gaps and issues manageable? Can the company increase its readiness level?

Yes

Create an alignment plans to increase the company readiness level and to fill the possible gaps

No

Does the alignment plan support the investment to achieve its strategic business objectives?

Yes

Based on the alignment plans, identify the expected full benefits, risks and strategic objectives

No

Take action by creating new alignment plan fit the company capabilities

No

Rejection of the investment Or Redesign a different alignment plan

Yes

Do the identified expected full benefits, risks and strategic objectives satisfy the board members?

Investment decision

Figure 8.1: Framework for technology investment decision-making
These elements are very significant in the successful technology investment decision-making process. Managing the five elements requires participation from all different levels within the organization, including the operational level, the managerial level and most importantly the executive level. The framework (see Figure 8.1) will be described in detail in this section.

**Justifying the investment**

Firstly, the company must identify the investment opportunity and its aspects, and the main requirements of the project. This should be followed by justifying the investment as the next step in the decision-making process. This can help to give decision makers an initial picture of the expected benefits from the investment, and clarify the validity of the investment. Justifying the investment must include strategic, financial and operational justifications to gain the most valuable information to support the investment decision. At this stage, the company must decide whether or not the justifications are convincing to them. If the company decision-makers are satisfied with the justifications, the company must start analysing more in-depth aspects regarding the investment details.

**Technology selection**

As a result of the justifications made, the company must go into more detail in planning for the investment. This must include identifying the project specifications, requirements and most importantly selecting the most appropriate technology. Therefore, to ensure the success of this step, the company must identify how well the selected technology can fit the project requirements and specifications. The decision makers must also look at the link between the selected technology and how it can contribute to achieving the company strategy and the strategic objectives of the investment. The required technology must be in line with the project specifications, and at this point the company must identify the requirements for the investment, such as resources, manpower, infrastructure and budget. Also, identifying the required technology will help to determine the level of abilities and readiness the company needs to achieve successful investment. If the technology does not
fit the project and the strategic objectives, the company must look for another similar technological solution. If this is not possible, no further analysis is required.

**Assessing company readiness**

After identifying the investment requirements, specifications and the selected technology, the company must work in assessing its readiness level to identify the gaps and difficulties that could affect the investment. This stage requires involvement from all company levels – operational, managerial and executive. It includes several aspects such as people readiness, culture, management, infrastructure, technology, operation, finance and work environment. Having identified the readiness level, the company must look at its capabilities and consider whether it can increase its readiness level and make it manageable. Once the company readiness level has been assessed, the company must start taking the required action to fill the readiness gaps to achieve successful investment. If the company realizes that it can increase its readiness level, the company can consider two different options. The first option is to take no further action; the second option is to change the technology to fit the readiness level.

**Technology alignment**

Assessing and creating alignment between the technology and the organization is an important step in resolving the issues and gaps found from the previous step that may affect the success of the investment. The company must create the required alignment plan based on the measured company readiness level and capabilities. The company must create an alignment plan that fits the strategic objectives of the investment and the company itself. If the company cannot achieve an alignment plan to resolve the issues found, the decision makers may create a new alignment plan by considering different solutions.
**Benefit realization**

Realizing the expected benefit from the investment is the last step before making the investment decision. As a result of the justification provided, the selected technology, the company readiness level and the planning for alignment, the company must identify the expected full benefits, risks and the possibility of achieving the strategic objectives from the investment. Therefore, based on the outcomes of benefit realization, decision makers can decide on the feasibility of the investment or a rejection of the investment.

### 8.4 Summary

In conclusion, this chapter has presented a discussion and recommendations of the findings of petrochemical companies decision-making processes in order to achieve the research objectives, questions and answers. Factors and issues have been discussed that could affect the decision-making progress and decision-makers’ planning for technology investment. The factors discussed and difficulties of the five different elements resulted in a framework that assists decision makers in making investment decisions. The following chapter aims to present the conclusion and future of this research.
Chapter Nine

Conclusion and Future Work
Chapter Nine

Conclusion and Future Work

9.1 Introduction

This chapter presents the conclusion of the conducted research and contributions to academic knowledge. The limitations of this research are also presented in this chapter. Finally, directions for future research are presented.

9.2 Research contributions

This research has contributed to knowledge by carrying out a number of important explorations. The most important contributions were in providing a detailed study and original explanation of the decision-making process in the petrochemical industry in Saudi Arabia. Issues and factors that are likely to influence the success of technology investment decisions were identified. Although all companies invested in new, advanced technology to increase their effectiveness, several gaps and difficulties in the decision-making process negatively affected the companies’ achievement of their objectives from the technology investment. The research provides explanations of factors and difficulties that relate to the decision-making process to enable decision makers and planners of the Saudi petrochemical companies to identify why their company is facing difficulties, and what specific actions might be taken to improve their investment decision-making process. In addition, this research expounds a combination of problems related to the key elements of decision making.

The study contributes to knowledge by investigating the decision-making process and the techniques applied in a range of petrochemical companies. The study highlights the
impact of five different elements that play a critical role in making an investment decision. The researcher investigated the techniques applied in four companies to justify their investment. The barriers that petrochemical companies faced in producing an effective project justification and an effective realization of the benefits have been identified. An investigation of the technology-selection criteria and process was conducted to identify key issues and their impact on the decision-making process. On the other hand, the research also contributed to knowledge by investigating the impact of the companies’ readiness and abilities in the success of their decision-making processes.

The research contributes to its context by exploring structures, and validating the influences of the investment decision-making process and technology investment within a specific context, which is the Saudi petrochemical industry. It was clearly observed that there is a lack of research about this subject in most countries and in Saudi Arabia specifically. As a result, the findings of this research can help the Saudi petrochemical companies and international petrochemical companies to achieve higher success rates with their investment decision-making processes and thereby contribute to increased competitiveness in this industry.

This research applied a number of methodologies and techniques to contribute to knowledge. A research case study allowed the researcher to examine the decision-making process from different angles and levels and to distinguish how the decisions are made and identify the possible gaps. The use of semi-structured interviews and free-flowing narratives allowed the researcher to build trust with the decision makers and planners within the investigated companies. This resulted in in-depth investigations and a gathering of information that reflects the respondents’ thinking. Therefore, the study contributes to knowledge by adding more detailed descriptive case studies than have been previously produced in the field of investment decision-making in Saudi Arabia.

Finally the research progress a framework to assist the petrochemical industry in future decision making. This show the steps which should be followed as sequence to achieve a successful final investment decision.
9.3 Limitations of the study and implications for further research

The outcomes and results produced in this research are limited in many ways. This study focused particularly on Saudi petrochemical companies. This then raises questions about the generalization of the outcomes of this research beyond the petrochemical industry. Future research is recommended to enable the generalization of this research to companies in other industries and sectors.

The outcomes of this research are limited by the researcher’s ability to obtain the required access to petrochemical companies, and the limited availability of the time of both the researcher and respondents in the first and second studies. Since studies and investigations of investment decision-making processes are rare in the petrochemical field, detailed and longitudinal studies could be useful to investigate the investment in the petrochemical industry from different perspectives. This could support researchers to follow possible changes in decision-making processes and the issues that may negatively affect the progress of the investment decisions.

Since this research focused on factors that affect the investment decision-making process in petrochemical companies, future research is recommended to investigate the following aspects and issues in decision making process:

- There is a need for an analysis of the strengths and weaknesses of the petrochemical industry in Saudi Arabia and their impact on the petrochemical company’s investments decision-making process.

- Studies are needed to investigate the affect of economic variables and financial crises in the previous and future investment decisions. Economic and financial information is important for such research but it is highly confidential.
• In-depth future research is required to investigate the link between the practice of decision making and the petrochemical company’s organizational performance. Longitudinal research can be applied to this issue to gain a better understanding.

• A forecast analysis can be conducted regarding the growth of the petrochemical industry and the relationship and impact of the applied decision-making process on industry growth.

• In-depth future research is needed to measure the impact of decision–makers’ knowledge, experience, and management style on the investment decision-making process.

• Investigation is required to measure the impact of the involvement of technologies and software in planning, analysing decisions and making final investment decisions.

• More longitudinal case studies are required to obtain a more comprehensive understanding of the organization’s culture influences, environment, processes, experience and their impact on the investment decision-making process.

• Future studies are needed to measure the level of impact of joint ventures and its impact on the success of the investment and the flexibility of the decision-making process.

• Comparative studies are also needed to compare the practice of investment decision- making between the Saudi petrochemical companies and European, Asian, and American companies.
References


223


Willcocks, L. (1991) Chairman’s introduction to a conference on Managing IT Investment, conducted by Business Intelligence, London


Websites


Appendix one (first study questionnaire)
Initial investigation of Technology investment decision making process

Purpose

The aim of this questionnaire is to address several objectives of PhD research study. The questionnaire intends to explore at an executive level the extent to which the decision-making activities, criteria and methods implemented by petrochemical companies are related to the efficacy of the decision-making process; and also, to identify the important internal and external factors that influence technology investment decision-making and evaluation practices in petrochemical companies. The objective of this questionnaire is to obtain valuable data to support all stages of the research.

The Content of the Questionnaire

The survey questions for participants were divided into three sections, namely the biographical details, the size and importance of the company investments, and the decision-making process applied within the company. Completion of the full survey and interview should take 1-2 hours.

Confidentiality Agreement

Data will be made anonymous (names and any other information that may identify an individual will not be included). For more information please contact Tariq.Alsahli@postgrad.manchester.ac.uk
About the organization

1. Name of the company?

2. What is your organization ownership structure? *(please select one)*
   - Private
   - Publicly listed
   - Government

3. What is the number of employee within your company?

4. What is the company annual revenue?

<table>
<thead>
<tr>
<th>Section one: The size and importance of the investment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1 Over the last five years, what percentage of your plant’s investment was spent in new manufacturing technologies?</td>
</tr>
<tr>
<td>1.2 What type of manufacturing technologies your company invested on in the last five years?</td>
</tr>
<tr>
<td>1.3 How important these investment to your company strategic objectives?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Section two: The applied and used decision making process within the company</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.1 Does your company have a formal process for making new manufacturing investments decisions? If so, please describe the typical process used by your company</td>
</tr>
<tr>
<td>2.2 What critical factors (e.g., organizational, operational, internal, external, etc.) are considered when your company planning for the new manufacturing investment decision?</td>
</tr>
<tr>
<td>2.3 What difficulties your company faced during the decision making process? Please explain</td>
</tr>
</tbody>
</table>
Appendix two (second study questionnaire)
In-depth investigation of factors and difficulties affecting technology investment decision making process

Purpose

This questionnaire aims to fully address the research objectives, and investigate in-depth, based on project level, the decision-making factors and difficulties and their impact on the direction of the decision-making process. The objective of this questionnaire is to obtain valuable recommendations for the petrochemical industry with regard to their technology investment decision-making processes.

The Content of the Questionnaire

The survey questions for participants were divided into five sections, namely the biographical details, the investment decision process, the investment benefit, investment justifications, the technology selection process, and company abilities. Completion of the full survey and interview should take 1-2 hours.

Confidentiality Agreement

Data will be made anonymous (names and any other information that may identify an individual will not be included). For more information please contact Tariq.Alshahli@postgrad.manchester.ac.uk
The aim of the following questions is to identify the applied process for an investment and what are the gaps and issues that the company faced during the stages of the decision process.

<table>
<thead>
<tr>
<th>Investment details</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the project name?</td>
</tr>
<tr>
<td>……………………………………………………………………………………………………………</td>
</tr>
<tr>
<td>Please explain where is the original idea of this investment came from?</td>
</tr>
<tr>
<td>……………………………………………………………………………………………………………</td>
</tr>
<tr>
<td>When did the project start?</td>
</tr>
<tr>
<td>……………………………………………………………………………………………………………</td>
</tr>
<tr>
<td>What is the approximate allocated budget for this project?</td>
</tr>
<tr>
<td>……………………………………………………………………………………………………………</td>
</tr>
<tr>
<td>What is the duration of this project?</td>
</tr>
<tr>
<td>……………………………………………………………………………………………………………</td>
</tr>
<tr>
<td>What are the proposed production activities of this project?</td>
</tr>
<tr>
<td>……………………………………………………………………………………………………………</td>
</tr>
<tr>
<td>What are the applied technologies in this project?</td>
</tr>
<tr>
<td>……………………………………………………………………………………………………………</td>
</tr>
</tbody>
</table>
Section one: The investment decision process

1. Please explain the applied decision making process for this project?

Section two: The investment benefit

2.10 In what stages did your company identify the expected benefit from this investment? Please explain

2.11 What process was used to identify the expected benefit from this investment? Please explain

2.12 What difficulties your company faced with the applied process?

2.13 Please identify what factors contributed to identify the expected benefits?

2.14 What are the realized benefits? And did you realize all the benefits? If not why?

2.15 If the realized benefit were less than what your company was expecting, why did this occur?

2.16 If the realized benefit were less than what your company was expecting, what actions did your company take as a result?

2.17 If the realized benefit were less than what your company was expecting, how did this affect how you made the subsequent investment decisions?
Section three: the investment justifications

3.1 Please explain what are the applied techniques for investment justification for this project?

3.2 To what level did these justifications take into account Corporate strategy?

3.2 To what level did these justifications take into account the company Financial performance?

3.2 To what level did these justifications take into account the company Operational performance?

3.3 What factors affected negatively the investment justifications?

3.4 What factors contributed to producing effective justifications to support the decision making process?

Section four: The technology selection process

1.3 What technology selection criteria were used for this investment?

1.4 What factors affected the ability to select the most appropriate technology? Please explain

1.5 How did these factors affect the decision progress? Please explain

Section five: The company abilities

5.1 Please explain how you identified the company’s ability to implement and adopt this investment?

5.2 What factors you did need to consider making the company ready for this project?

5.3 What barriers affected your plans to increase the company ability level?
5.4 Did the company ability level affect your decision direction? Please explain.

5.5 In the following areas, please identify any actions taken to prepare the company for the project.

(a) What actions were taken to solve the people issues?
(b) What actions were taken to solve technical and operations issues?
(c) What actions were taken to bridge the gaps between the business process and this project?
(d) What actions were taken to solve the organizational structure issues?
(e) What actions were taken to solve finance difficulties?

5.6 Please identify what difficulties affected the required actions for the above areas.
Appendix three

Terms and definitions
### Terms and definitions

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joint venture</td>
<td>Joint venture in manufacturing technologies has described by Management World, (1996) as a way to reduce the risk of the investment and sharing of the responsibilities which is may result a higher success rate of the project.</td>
</tr>
<tr>
<td>Production costs</td>
<td>Tayyari and Kroll, (1990), claimed that the production costs include material, labour, inventory, and maintenance.</td>
</tr>
<tr>
<td>Operational cost</td>
<td>Mani et al. (2006) The operating cost includes the cost of the raw material, energy cost, electricity cost, and personnel costs.</td>
</tr>
<tr>
<td>Hidden cost</td>
<td>Willcocks (1991), the cost of operations and maintenance costs may contain hidden and unseen cost, and these may amount to as much as 2 to 10 times the development and installation costs.</td>
</tr>
</tbody>
</table>