DECISION FACTORS FOR OUTSOURCING THE MAINTENANCE SERVICES OF SAUDI UNIVERSITIES

BY

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I dedicate this thesis to my father, my mother and family

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Thesis Abstract

Name: **Ahmed A. Al-Nehmi**

Title: **Decision Factors for Outsourcing the Maintenance Services of Saudi Universities**

Major Field: **Architectural Engineering**

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The objectives of this thesis are to identify and assess the factors influencing the decision to outsource and also to develop a decision-making framework for outsourcing of the maintenance services in Saudi universities. The methodology adopted in this research consists of two phases. First, the research focused on acquiring the knowledge through an extensive literature review about the outsourcing decision factors from the viewpoint of researchers. Then, interviews were conducted with two maintenance department managers in KFUPM & KFU for a pilot study, and surveys were carried out at eleven Saudi universities. This resulted in identifying thirty-eight factors classified under six categories namely: Strategic, Management, Technological, Quality, Economic, and Function Characteristics. In the second phase, the Analytic Hierarchy Process (AHP) was used to establish weights and priorities of the factors. Participants agreed on Quality and then Cost as the most important categories, and outsource the maintenance services with priority of 77%. Participants ranked "Improve quality requirements" and "Achieve quality for competitive advantage" as the most important factors for the outsourcing decision. Then the AHP method was used to construct the framework for decision-making the outsourcing of the maintenance services of Saudi universities. Finally, some recommendations are given. The findings may provide value for the universities in Saudi Arabia confronted with the decision of whether or not to outsource.

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ملخص الدراسة

الاســـــــــم: **أحمد عبدربة علي النهمي**

عنوان الرسالة: **دراسة العوامل المؤثرة على قرار استخدام مصدر خارجي (مقاولين) لاداء خدماتِ الصيانة في الجامعاتِ السعوديةِ**

التخصـــــص: **هندسة معمارية**

تاريخ التخـرج: **1430 هجرية**

تبنى أهدافَ هذه الأطروحة على تُقيّمَ العوامل الحاسمة المؤثرة على قرار استخدام الجامعات السعودية لمصدر خارجي (مقاولين) لأداء خدماتِ إعمال الصيانة و تُطوّرُ إطار عمل لإتّخاذ قرار استخدام الجامعات لمصدر خارجي.

المنهجية المتبعة في هذا البحثِ تَشْملُ مرحلتين: المرحلة الأولى مراجعة الدراسات السابقة و اجراء مقابلات شخصية مع مدراء الصيانة في كل من جامعة الملك فهد للبترول والمعادن و جامعة الملك فيصل ثم عمل مسح من خلال استبيان لتقييم العواملَ التي تُؤثّرُ على القرار في إحدى عشر جامعةِ سعودية وشمل الاستبيان 38 عامل صنفت تحت ستّ فئات: الإستراتيجية، الإدارية، التقنية، النوعية أو الجودة، الاقتصادية، خصائص الخدمةِ. المرحلة الثانية تم استخدام عملية التدرج التحليليةِ (AHP) للعوامل بواسطة استخدام برنامج (Expert Choice) لتَأسيس وَزْن وأولوياتِ العوامل المؤثرة ومستوى أهمية هذه العوامل ثم تم تطوير اطار عمل متكامل لقرار استخدام مقاول او تأدية الخدمة داخليا .

فقد تم الإجماع على أن أهم العوامل هي: تحسين متطلبات الجودة (النوعية) في خدمة الصيانة و تقديم خدمة تنافسية للتكيف مع التغيرات غير المتوقعة و استمرار النوعية العالية أهم العوامل المؤثرة, كذلك قيمت الجودة في خدمات الصيانة ثم تقليل الكلفة كأهم عاملين رئيسية يليهما العامل الاستراتيجي, و بقرار أداء خدمات الصيانة بواسطة مصدر خارجي (مقاولين) بنسبة 77%. اخيرا اعطيت بعض التوصيات لاقسام الصيانة و البحوث المستقبلية. نتائج الدراسةِ سوف تُزوّدُ الجامعات في المملكة العربية السعودية بمجابهة قرار استخدامها (لمصدر خارجي او تأدية الخدمة داخليا) لأداء خدماتِ إعمال الصيانة.

درجة الماجستير في العلوم

جامعة الملك فهد للبترول و المعادن

الظهران. المملكة العربية السعودية

CHAPTER ONE

INTRODUCTION

1.1 Background

A new activity called outsourcing entered the world of business around 1975, and since then it has become one of the dominant trends (Fill and Visser, 2000), as it is shifting the way that organizations secure support services. By focusing on core functions or the main purpose, an organization can get many benefits through engagement of specialists who consider non-core activity as their main interest (Craig, 2002).

Facilities can be considered as assets or property investments needing to be maintained regularly to ensure their optimal value over their life cycle (Hassanain et al., 2003). Facilities' performance starts to decline immediately after they come into use and at that time the need for maintenance begins (Arditi and Nawakorawit, 1999). According to British Standard 3811 (‘‘Glossary’’, 1984), building maintenance is defined as ‘‘a combination of all technical and associated administrative actions carried out to retain an item in, or restore it to, an acceptable condition.’’ Maintenance of facilities includes cleaning, inspecting, repairing and replacing the components (Arditi and Nawakorawit, 1999). Facilities will continue to be occupied and operate well only if they are properly maintained. Therefore, effective maintenance is necessary to keep up the appearance and efficiency of the facility, to operate all systems and components efficiently, and to keep the interior and exterior clean and safe. In many instances, owners and users of buildings

spend billions of dollars each year on replacement components for their buildings (Arditi and Nawakorawit, 1999).

Saudi Arabia's economy is now one of the 20 largest in the world (Ministry of Planning, 1990). Therefore, the Kingdom has seen tremendous development over the recent years. The government has effectively used its income to improve the citizen's life style; by building universities, hospitals, airports, electricity and telephone networks to meet the rapid urban development. These facilities need to be maintained effectively to ensure that they optimally serve the main purpose (Al-Sultan, 1996).

1.2 Statement of the Problem

Saudi Arabia is devoting significant attention to developing higher education. Established in 1975, the Ministry of Higher Education embarked on a long-term master plan to enable the Saudi educational system to provide the highly trained manpower necessary to run the country's increasingly sophisticated economy. By 1999, there were eight key universities and several other institutions of higher education. By 2003, there were also several private institutes of higher education, with more planned (Ministry of Education, 2008). The number of universities founded over the past 10 years in the Kingdom has been increased to eighteen universities. Having a diverse set of infrastructural facilities, a university campus can be viewed as a city within the fabric of the metropolitan city it is located in. Diverse sets of infrastructural facilities include: educational and administration buildings; students and faculty housing; and utilities and services networks.

Maintenance issues are considered as vital elements for facilities to ensure the efficiency of performance. Maintenance of facilities can be achieved by three means, namely: in-house maintenance, outsourcing, and a combination of in-house and outsourcing. Universities consider outsourcing of operating units or functions where such outsourcing could get better efficiency and effectiveness and let the university focus its effort on core activities such as education, research, community service and the managerial support of that mission. Maintenance is frequently defined as a non-core activity, so that outsourcing allows the management to focus its resources on those activities that are truly core. Decision-making for outsourcing is considered as a vital management process, and a range of practical methods must be developed to improve decision-making. The decision whether or not to outsource is a complex one, and there are many factors that play a role on all levels (McIvor et al. 1997).

Before any serious steps are taken towards outsourcing, an overall plan of the outsourcing process must be developed. This plan should involve the outsourcing decision, and factors affecting this decision, to complete the support for the management and to ensure full participation of the parties most affected (Campbell, 1995). This study focuses on the crucial factors that are considered to decide whether to outsource or not. The Analytic Hierarchy Process (AHP) is introduced as a suitable and helpful approach to the complexity of the outsourcing decision-making factors. This study then concentrates on identifying the factors affecting the decisions on outsourcing the maintenance services in Saudi universities and ranking the most important factors by using the AHP method.

1.3 Research Objectives

The main objectives of this research are:

1. Assess the frequency of outsourcing the maintenance services of Saudi universities to specialty contractors.
2. Identify and assess the crucial factors influencing the decisions to outsource the maintenance services of Saudi universities.
3. Develop a decision-making framework for the outsourcing of maintenance services of Saudi universities.
4. Demonstrate the applicability of the developed framework by conducting a case-study to investigate the decision process of whether or not to outsource the maintenance of HVAC systems.

1.4 Scope and Limitations

The scope and limitations of this research are as follows:

1. To identify the factors that influence the outsourcing decision process, this research will analyze the published literature.

2. This research will conduct a pilot-test of the developed questionnaire in two universities:

   a. King Fahd University of Petroleum and Minerals

   b. King Faisal University

3. The research will aim to obtain responses on the developed set of questionnaire surveys from the following Saudi Arabian Universities:

   a. Umm Al-Qura University

b. King Abdul Aziz University

c. King Fahd University of Petroleum and Minerals

d. King Faisal University

e. King Saud University

f. King Khalid University

g. Imam Muhammad bin Saud Islamic University

h. Taif University

i. Qasim University

j. Islamic University of Al-Madinah Al-Munawarah

k. Najran University

1.5 Methodology

To achieve the objectives of the thesis the research plan consists of five main phases. These phases are illustrated in Figure 1.1, and described as follows:

1.5.1 Phase 1: Literature Review

This phase involves reviewing the state-of-the-art literature in the fields of maintenance management and outsourcing practices to:

- Achieve a thorough understanding of the issues involved.
- Identify the crucial factors affecting the outsourcing decision of maintenance services.

1.5.2 Phase 2: Data Collection

This phase involves two research activities, as follows:

1.5.2.1 Development of Questionnaire Surveys

Two questionnaire surveys were developed for the following purposes:

- The first survey served the purpose of assessing the frequency of outsourcing the maintenance services of Saudi Arabian universities.
- The second survey was developed to assess each crucial factor influencing the decision to outsource the maintenance services of Saudi Arabian universities. Data obtained through this survey were of two types: general information about the respondents, and technical information for pairwise comparison of the factors and their classifications into categories.

Respondents to these questionnaires were maintenance department managers in Saudi Arabian universities. The questionnaires surveys are included in Appendixes I, II and III.

1.5.2.2 Pilot-Testing of the Developed Questionnaire Surveys

The two developed questionnaire surveys were pilot-tested through:

- Interviews with the managers of the maintenance departments in two universities (King Fahd University of Petroleum and Minerals, and King Faisal University) selected due to their geographical proximity.
- Refining the questionnaire surveys to incorporate the comments obtained from the above-mentioned maintenance department managers.

1.5.3 Phase 3: Data Analysis

This phase used two methods for data analysis (Statistical Analysis, and AHP with Expert Choice Software) as follows:

1.5.3.1 Statistical Analysis Method

Statistical Analysis Method was applied to the first questionnaire survey to identify the frequency of outsourcing the maintenance services by using a 5-points scale. The weighted mean, standard deviation and severity indices were calculated.

1.5.3.2 AHP Method and Expert Choice Software

AHP was used to analyze the second questionnaire survey, using EXPERT CHOICE software, to assess the crucial factors influencing the decision to outsource the maintenance services of Saudi Arabian universities. AHP was used to develop a decision-making framework for this outsourcing, and to rank all factors influencing the decision.

1.5.4 Phase 5: Development of Framework

This phase involves developing a decision-making framework for outsourcing the maintenance services of Saudi Arabian universities.

1.5.5 Phase 5: Development of Case Study

This phase involves demonstrating the applicability of the developed framework by conducting a case-study to investigate the process of deciding whether or not to outsource the maintenance of HVAC systems in the Maintenance Department of King Fahd University of Petroleum and Minerals.

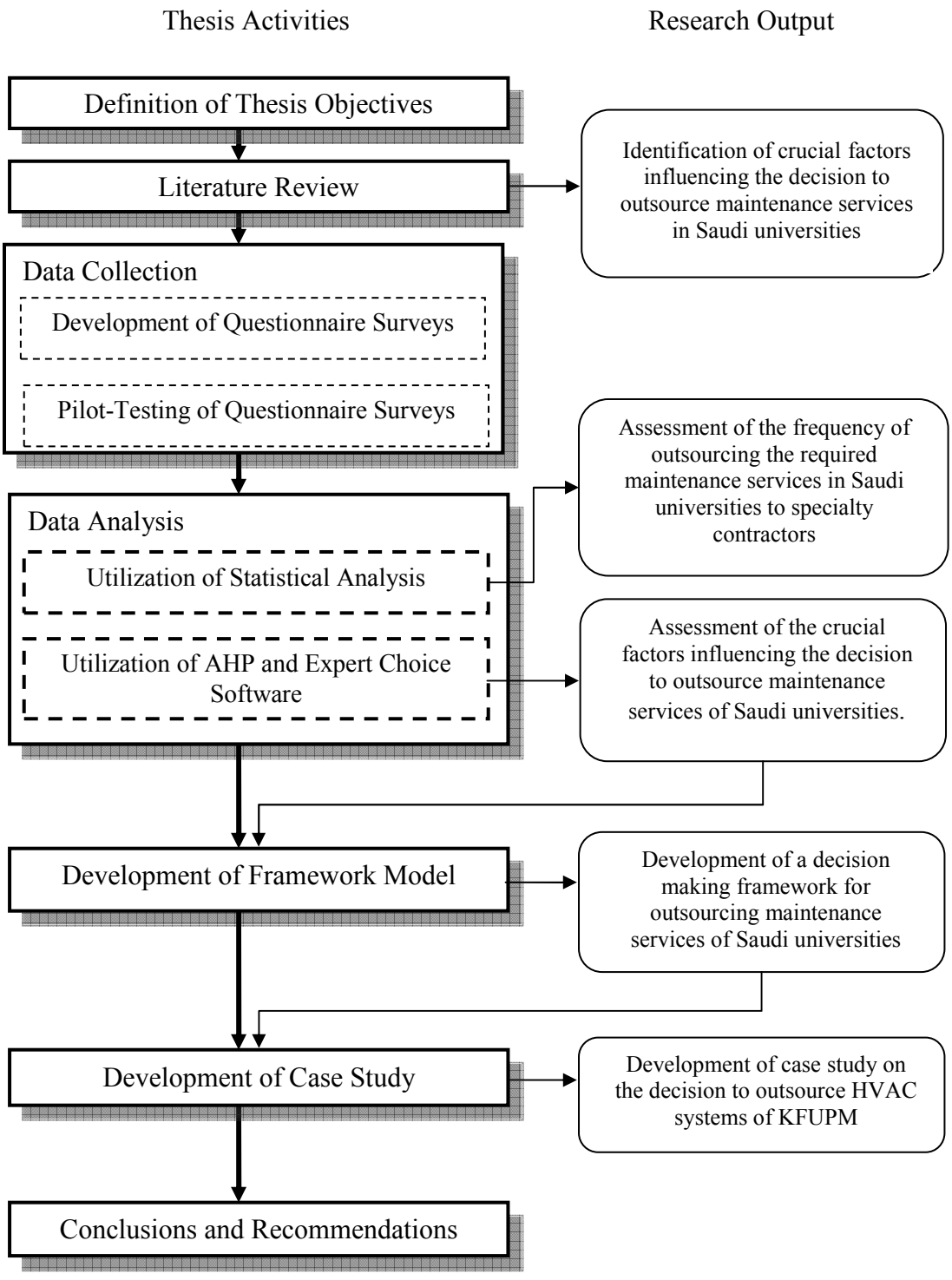

Figure 1.1: Methodology Chart

1.6 Significance of the Study

The significance of the study stems from the following:

- Universities expect to gain many benefits through successful outsourcing for their maintenance services, although there are risks and repercussions if the outsourcing decision is not planned and organized.
- Assessing the frequency of outsourcing the maintenance services of Saudi universities to demonstrate which the type of service is mostly outsourced.
- Assessing the most important factors influencing the outsourcing decision for the maintenance services of Saudi Arabia universities.
- While universities are faced with increasing opportunities to outsource their maintenance services, there remains a need to develop a framework for making the outsourcing decision.
- To show several important findings related to the outsourcing of maintenance services.
- The findings of the study are relevant and applicable to other universities in Saudi Arabia.

1.7 Structure of the Thesis

The thesis is organized as follows:

Chapter 1: Introduction

This chapter provides background to the topic, and it presents an overview of the problem, the research objectives, the methodology, the significance of the study, and the scope and limitations of the research.

Chapter 2: Literature Review

This chapter reviews the literature review on the outsourcing of maintenance services, the growth of maintenance in Saudi Arabia, and the decision-making methods, including AHP, and Expert Choice (EC) software.

Chapter 3: Factors in Decisions on Outsourcing

This chapter defines the factors which have the greatest influence on the outsourcing decisions for maintenance services of Saudi universities.

Chapter 4: Research Methodology

This chapter presents the methodology adopted in the study to achieve the thesis objectives.

Chapter 5: Data Analysis and Results

This chapter presents the AHP techniques and Expert Choice (EC) software used for the analysis, results, and major findings.

Chapter 6: Framework for Outsourcing Decision of Maintenance Services

This chapter presents the development of the framework of decision-making for outsourcing the maintenance services, and it describes a case-study on the decision to outsource HVAC systems at KFUPM.

Chapter 7: Conclusions and Recommendations

This chapter outlines the conclusions, summarizing of present study, and makes recommendations for future studies.

CHAPTER TWO

LITERATURE REVIEW

2.1 Previous Studies

Many studies have been completed on various aspects of outsourcing. Examples are:

Campbell (1995) stated that a planned outsourcing strategy can deliver a competitive advantage by making an organization focus on core-activities. He stated that it is important to assess the organization's readiness to introduce outsourcing, as well as to identify the activities which offer the best potential to the organization.

Abdelrazig (1995) presented a structured methodology to help contractors in Saudi Arabia to make their bid/no-bid decisions by using the AHP method. The computer software Expert Choice based on the AHP and the bid/no-bid decision was used to solve the bid/no-bid decision model.

Udo (1996) used AHP to propose a suitable information system outsourcing decision model, and he grouped the determinants into vendor issues, strategic importance, customer interests, and employee interests. He stated that AHP has the advantage of handling complex qualitative variables involved in the decision-making analysis.

Lonsdale (1999) proposed a risk-minimizing approach to outsourcing. He suggested that many issues should be included: the quality of cost accounting systems, the loss of skills, and falls in employee morale. His model recommended understanding the sources of the organization's competitive advantage and realizing the potential for dependency.

Ketler and Walstrom (1999) conducted a survey to determine the factors affecting the outsourcing decision. Their study yielded three crucial factors:

- Cost savings.
- Access to increased knowledge and expertise.
- Availability and quality of vendors.

Arditi and Nawakorawit (1999) conducted a survey of 230 property management organizations in the United States to examine their maintenance practices. The findings concentrated on the policies concerning outsourcing and in-house maintenance services. They found that corrective maintenance, service maintenance, and deferred maintenance are mostly performed by outsourcing. Routine maintenance and preventive maintenance are mostly performed by in-house staff. Extraordinary maintenance is mostly performed by contractors. Cleaning the interior is performed by staffs, but the exterior is cleaned by outsourcing. Inspection, repair and replacement of building components are performed by outsourcing.

Quinn (2000) stated that outsourcing has many advantages including: flexibility, access to scale economies, the ability to focus on the remaining specialized functions, reduction in overheads, and development of flatter and more responsive organization.

Yang and Huang (2000) stated that five factors (strategy, economics, technology, management, and quality) should be considered for decisions on outsourcing. They used the analytic hierarchy process (AHP) method in structuring the outsourcing problems. There are many benefits when the firms adopt outsourcing including: cost savings, strategic fitness, improved management effectiveness, technology upgrade, and the service quality.

Fill and Visser (2000) developed a "composite outsourcing decision framework", as a tool to help managers to appraise the issues to be considered, whose main aspects are: costs, investments, strategic interest, confidentiality, and stability of employment.

Arnold (2000) developed an integrated model for outsourcing decision-making, by using both transaction cost economics and a core competence approach. His model used design alternatives based on institutional economic theory to make concrete recommendations for outsourcing. His model consisted of four major elements: subject, object, partner, and design.

Buys and Nkado (2000) revealed that the majority of organizations use in-house staff for minor maintenance but outsourcing for major maintenance. Lack of management

staff, as well as lack of funds, was found to be the most important troubles experienced by maintenance departments. They reported that financial systems, quality maintenance tools, priorities for maintenance, budgeting and sustained top management are the five most important criteria for best practice in maintenance management.

Jennings (2002) assumed that outsourcing is undertaken to achieve competitive advantage for organizations. He developed a conceptual model that considers an organization's capability and its competitive environment.

Bertolini et al. (2004) analyzed maintenance outsourcing by means of AHP technique for managerial decisions to select the best alternative between different outsourcing contracts in terms of maintenance functions. The AHP is able to support the choice of the level of the maintenance activities being outsourced. In particular, the hierarchic decisional structure gives a well balanced synthesis of the various factors that must be taken into account during this type of decision process. They stated that the decision on the maintenance outsourcing was executed by using cost-based decision models. They analyzed the decisions on maintenance outsourcing by taking into account complex sets of factors.

Hui and Tsang (2004) identified four strategies to perform maintenance service management, namely in-sourcing, out-tasking, outsourcing for cost saving, and outsourcing for capability. They developed a framework that can be used for the selection

of an appropriate sourcing strategy, and they provided guidelines for implementing the selected sourcing option.

Through six case studies, Lau and Zhang (2006) explored the key drivers of outsourcing and the obstacles faced by organizations in China. They indicated that economic, strategic, and environmental factors are the dominant in the outsourcing decision, and the drivers of outsourcing can be grouped into these categories. Successful outsourcing helps achieve various goals, resulting in cost savings or efficiency improvements which lead to a competitive advantage.

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Kremic (2006) stated that the factors to be considered when making the outsourcing decision include: the relative costs of performing the function, how core is the function to the organization, the long-term strategy, and the environmental factors. He presented the possible benefits, risks, and strategic issues of outsourcing, and he stated that the literature lacks guidelines on sustainable decisions and it needs further work.

2.2 Maintenance

2.2.1 Introduction

Maintenance is the performing of all actions to restore items, components or equipment in specified operational conditions. Maintenance is a key factor in extending the economic life for buildings, and so the main causes of maintenance improvement are emotions and economics (Patton, 1988). For achieving world-class performance, organizations have to undertake efforts to get better quality and reduce costs, for instance

by inspecting the activities of the maintenance services that are crucial for many operations (Swanson, 2001).

2.2.2 Maintenance Objectives

The primary objective of maintenance is to preserve the asset to ensure that it serves its anticipated purpose (Arditi et al, 1999). The other objectives of maintenance are as follows (Al-Najjar, 1996; Magee, 1988):

- Improving quality rate and effective control for process.
- Improving the work environment.
- Ensuring the safety of occupants using facilities.
- Extending the useful life of items and components.
- Higher product and machinery reliability.
- Ensuring readiness of equipment and tools needed for emergency use.
- Operate the facility utilities in the most economical way.
- To ensure that the condition of the building meets all statutory requirements.

2.2.3 Maintenance Types and Methods

The maintenance process is performed as follows: When a problem is detected, it is necessary to determine its cause, so that it can be quickly corrected or reinstalled (Patton, 1988). There are many methods and types of maintenance. The following represents most of them (Mostafa, 2004):

- **Run-to-failure:** This method is suitable for minor corrective work, low price equipment and components.
- **Corrective maintenance:** This is done after a failure, to restore an item to a state in which it can perform its required function.
- **Scheduled maintenance:** Periodic inspection of facilities and replacement of components (Kececioglu, 1994).
- **Planned maintenance:** This is carried out with foresight, control and the use of records to a predetermined plan.
- **Preventive maintenance:** This keeps a facility operating efficiently through regular inspection, and it aims to tackle small problems before they become expensive.
- **Condition-based maintenance:** If maintenance is based on expected failure of the component, it includes scheduled and corrective maintenance.
- **Predictive condition monitoring:** This is performed by the application of multiple technologies to monitor the condition of items.
- **Reliability-centered maintenance:** This method is used to determine the maintenance requirements of any asset in its operating context (Moubray, 1993), and to improve the asset promptly instead of rectifying it in the future (Al-Najjar, 1996).
- **Total productive maintenance:** This includes many methods to improve reliability, quality, and production (Al-Najjar, 1996). By combining with the effort of operators for safety, and quality.
- **Operating and maintenance training and administration:** This considers the four integral parts of the maintenance system.

- **Proactive maintenance:** This reduces the total maintenance required through advanced performance including preventive/ predictive maintenance.
- **Maintenance management metric:** This allocates the value-added resources for improving component's overall effectiveness, and optimizing the cost per unit of production.
- **Total quality maintenance:** Total quality maintenance is a method for monitoring and controlling deviations in a service's quality by detecting and preventing the causes of failure. By this a strategy, the user maintains the technical and economic effectiveness of the process elements (Al-Najjar, 1996).

2.2.4 Maintenance in Saudi Arabia

Saudi Arabia has witnessed a high level of development, and it is the biggest member of the Organization of the Petroleum Exporting Countries (OPEC). Over the past decade, oil prices have been relatively low, and the Kingdom's revenue has decreased noticeably (Al-Sultan, 1996). As a result, the likelihood of replacing old facilities has been deeply reduced except in severe cases. The Kingdom will have to sustain and improve the existing infrastructure. Maintenance is therefore vital, but its cost is increasing. Therefore the Kingdom has to find methods of reducing the costs of maintenance while maintaining the same quality of services (Al-Sultan, 1996).

When analyzing the budget of the construction and the budget of maintenance, the huge growth is noticed. From the Table 2.1, the budget for construction industry was SR 2.411 billion in 1391 H, but it rose to SR 89.91 billion by 1402 H (Ministry of Planing, 1995). The Maintenance industry grew from SR 327.6 million in 1391H to SR 2,348.9

million in 1402H. When comparing budgets for maintenance with budgets for construction, the accumulated construction budgets should be considered. The cost of maintenance and running costs are a nearly half of the total cost of a facility, and the initial cost comprises the other half (Mahmoud, 1994).

Table 2.1: Maintenance and Construction Expenditures (Mahmoud, 1994)

Year (H)	Budget for Maintenance in Million SR	Budget for Construction in Million SR	Accumulative for Construction (Million SR)	% of Maintenance to Accumulated Construction.	Maintenance Needed for 1.25 % Adjustment	Amount Required for 1.25 % (Millions)	Difference Between Required & Actual (Millions)
1391	327.6	2411	2,411	13.6%	-	-	-
1392	425.8	3,543	5,954	7.2 %	-	-	-
1393	533.3	5,506	11,460	4.7 %	-	-	-
1394	686.4	9,645	21,105	3.3 %	-	-	-
1395	191.2	20,369	41,474	0.5 %	0.75%	518.4	311.1
1396	205.8	33,501	74,975	0.3 %	0.95%	937.2	712.2
1397	197.0	46,606	121,581	0.16 %	1.09%	1,519.8	1,325.2
1398	420.5	60,045	181,626	0.23 %	1.02%	2,270.3	1,852.6
1399	609.9	69,789	251,415	0.24 %	1.01%	3,142.7	2,539.3
1400	1,497.1	80,157	331,572	0.45 %	0.80%	4,144.7	2,652.6
1401	2,001.6	89,740	421,312	0.48 %	0.77%	5,266.4	3,244.1
1402	2,348.9	89,911	511,223	0.45%	0.80%	6,390.3	4,089.8
						Total	**16,726.9**

2.2.5 Selection of Maintenance Contractors

The selection of maintenance contractors depends on their ability. The following are general criteria in the selection of contractor (Chanter, 1996; Bertolini et al., 2004):

- Reputation
- Geographical position
- Perceived quality services
- Contractor resources
- Workload and availability
- Technical excellence
- Low price

2.2.6 Contracts of Maintenance Services

Martin (1997) classifies maintenance contracts into three types: work-package contracts, performance contracts and facilitator contracts. A description of each is provided as follows:

- **Performance contracts:** This applies where the complete maintenance services are awarded to a contractor.
- **Facilitator contracts:** The client is only the user of the physical assets, whereas they are owned and maintained by the contractors.
- **Work-package contracts:** Design and planning of the maintenance are performed by the client, who informs the contractors about the time that is needed to do maintenance services.

Maintenance can be organized by a variety of contracts, as follows (Chanter, 1996):

- **Fixed price contracts:** The price is agreed and fixed before the contract is signed.
- **Lump sum contracts:** The contractor receives a set amount as payment for delivering works to the owner. The contract price includes the contractor's reimbursement and his profit.
- **Term contracts:** The contractor must carry out certain types of work within certain limits of cost for an agreed period. The work is usually priced on either a measured term or day-work term.
- **Cost plus contract:** There are three types in this category (Mahmoud, 1994):
    1. **Cost plus fixed contracts:** The contractor is reimbursed for actual allowable costs, and he receives a fixed percentage of the contract value as his fee or profit.
    2. **Cost plus fluctuating free contracts:** A contractor is paid the actual cost of the work plus a fee.
    3. **Cost plus percentage contracts:** The contractor is paid the actual cost of the work, plus an agreed percentage of the actual cost.

2.3 Outsourcing

2.3.1 Definition of Outsourcing

Outsourcing is a process of transferring some activities to outside contractors in order to gain various benefits such as better services and lower costs (Graham, 1996). It is defined as the process by which a client employs a separate company, under a contract, to execute a function previously done in-house (Barret and Baldry, 2003). Outsourcing

has become an important organization approach, and many advantages are gained, such as performing a service more effectively and efficiently. Outsourcing is related to the process called "contracting-out" and these two terms are sometimes used interchangeably (Martin 1997). However, contracting-out is usually arranged before the organization does that specific task. The organization determines a service and gets a contractor to perform it. Therefore, the responsibility is left to the service provider. This is what differentiates outsourcing from “contracting-out” (Klammat, 2001).

All the organization’s activities are classified into four types: core activities, core-close activities, core-distinct activities, and disposable activities (Arnold, 2000; Lindskog, 2005). Outsourcing may include all activities required for an organization’s existence, except its core activities. Many of the arguments over whether or not a function should be outsourced are based on the core versus non-core organization analysis (Beitz, 1998).

2.3.2 Organization Readiness

Outsourcing can be considered as an effective opportunity to save cost and to improve service quality. However, the decision on outsourcing should be carefully studied by identifying the circumstances and assessing organization's readiness for outsourcing. This readiness can be assessed by establishing that there are issues which outsourcing can resolve and by attempting to measure all the associated costs. Readiness depends also on the capability of the market and on the cost-effectiveness of outsourcing

as a means to accomplish the objectives of organization (Campbell, 1995; McIvor et al., 1997).

2.3.3 Typical Outsourced Maintenance Activities

The outsourced activities vary from one organization to another, depending on the type and size of the organization. After the organization's core activities are identified, its non-core activities are evaluated and outsourced. Maintenance may be considered non-core for organizations, but it may be the core activity of a maintenance organization. The major tasks of maintenance are (Patton, 1988): removal, removal and replacement, removal reinstallation, repair, adjustment, refurbishing, and inspection. Maintenance works include many types (OCSB, 2008):

- Air conditioning and ventilation system
- Fire system and lift and elevators
- Plumbing sanitary system
- Electrical system
- To provide operational manpower
- To provide spares and rectification
- Repairing internal and external
- Facial uplift
- Maintenance of tiles, roofing, waterproofing and roadwork
- Replacement
- Interior decoration for property owner

- Renovation work based on cost reimbursement
- Cleaning and providing cleaning chemicals
- Landscaping works
- Providing potted plants
- Providing toilet building maintenance
- Waste disposal
- Security and parking

2.3.4 What Caused Outsourcing

In today's markets, the competition amongst organizations is extremely high. This competition enables the customers to insist on reliable services, and high quality products. To achieve this result, the organizations are driven to outsource their non-core functions so as to focus on their core functions. However, the distinction between core and non-core functions needs more attention. If an organization succeeds in disaggregating these activities, the non-core functions should be outsourced (Barret and Baldry, 2003).

2.3.5 Reasons of Outsourcing

Outsourcing can provide specialized expertise which organizations cannot justify developing in-house. Outsourcing is not only for cost-saving, but is also an integral part of the overall strategy to concentrate on core functions. Organizations which outsource some activities have many reasons for doing so (Beitz, 1997). By outsourcing, a higher level of expertise can be obtained at a lower cost. Outside experts can not only help in re-

engineering processes to make them more efficient, but they can also apply the most useful new technology and ultimately raise flexibility and productivity to reduce the overall costs. Outsourcing allows organizations to redirect their resources from non-core to primary activities, thus maximizing performance (Quinn, 1999). The survey by the Plant Maintenance Resource Center (2001) reports the following reasons to outsource:

- Increase labour productivity
- Reduce maintenance costs
- Focus in-house personnel on "core" activities
- Improve work quality
- Reduce influence of trade unions
- Improve environmental performance
- Keep pace with rapidly changing technology
- Obtain specialist skills not available in-house
- Increase access to specialist equipment
- Improve equipment uptime/performance
- Reduce risk

2.3.6 Advantages of Outsourcing

An organization should benefit from outsourcing when the task is precisely specified, performance is accurately evaluated, and there is competition from bidders (Beitz, 1998). The benefits that may be gained through outsourcing include:

- **Reduce the overall operation cost:** The cost is the main drive to outsource a service delivers it at an acceptable rate (Jennings, 2002; Lankford and Parsa, 1999).
- **Improve the quality of services:** Outsourcing is a method to improve and sustain the quality of services (Campbell, 1995; Kremic, 2006).
- **Expertise and knowledge:** Outsourcing should provide knowledge and expertise in complex services, so that the in-house staff can upgrade their skills and knowledge. (Campbell, 1995).
- **Solve the skill shortage:** The contractor has specialized manpower to supplement the skills available in the organization (Quinn, 1999).
- **Focus on core activities:** Organizations need to focus on their core activities. If the core and non-core activities are well identified, outsourcing the non-core activities will help achieve this focus (Jennings, 2002).
- **Reduce/share risks:** Facilities management becomes complex especially in a hazardous environment and interruptions dissatisfy the customer. Therefore, an organization uses outsourcing to spread or reduce these risks.

2.3.7 Disadvantages of Outsourcing

Outsourcing can produce many advantages, or it can bring problems. The following are some of the disadvantages:

- **Monitoring costs:** The organization might incur costs to make sure that an outsourced function is delivered at the required quality level and at the right time (Yik, 2005).

- **Transaction costs**: To find a suitable contractor, the investment involves the cost of transferring of assets to the contractor and then the on-going provision of services (Graham, 1996 and Lindskog, 2005).
- **Motivation is reduced:** If outsourcing involves transferring people to the contractor, the organization cannot motivate them (Bertolini et al., 2004).
- **The loss of control:** Once a function is transferred to the contractor, the flexibility of control will be limited to the contract (Lau and Zhang, 2006)).
- **Loss of collective knowledge:** The knowledge about a facility and the function is no longer kept in an organization. If the organization wants any information then it has to go back to the contractor (Kremic, 2006).
- **Loss of in-house skills/expertise:** When the management of function is totally transferred to the contractor, the internal employees lose their expertise (Campbell, 1995).
- **Security risks/threats to confidentiality:** Introducing contractors to the site means secrets are becoming known by others, and thus risks are raised (Graham, 1996; Alexander, 1996).

2.4 Decision Making

2.4.1 Introduction

Decision making is the study of identifying and choosing alternatives based on the preferences of the decision maker (Baker et al., 2001). In this section, the analytic hierarchy process (AEP), Expert choice software, and decision making techniques and methods are discussed.

2.4.2 Decision Making for Outsourcing

Before the 1970s, outsourcing was adopted to reduce costs (McIvor et al., 1997). Today, it is usually supported by many factors in all organization levels. The decision to outsource should take account of many issues: scale economy, outsourcer expertise, strategy, the need for cost savings, accountability with greater control of operating costs, moving from fixed into variable costs, and quality factors (Lankford and Parsa, 1999).

2.4.3 Decision Making Techniques and Methods

Decision making techniques are systematic procedures that adapt critical thinking to data, so as to choose between alternatives. Many methods are used for solving decision making (Baker et al., 2001):

2.4.3.1 Kepner-Tregoe Decision Analysis (K-T)

This method uses a quantitative comparison through numerical scoring if criteria based on individual judgments of the experts. Each criterion is scored by its relative importance to the other criteria. The quality of the data depends on the team's size. The more intangible and qualitative the data, the more participants should be involved. K-T is suitable for reasonably complex decisions involving a few criteria (Baker et al., 2001).

2.4.3.2 Multi-Attribute Utility Theory Analysis

MAUT, sometimes called Grid Analysis, is a quantitative comparison method used to combine different measures (MT, 2008). It uses the utility functions that transform the raw performance values of the alternatives against diverse criteria to a

common dimensionless scale. Utility functions convert the raw performance values so that a preferred performance obtains a higher utility value. MAUT is suitable for complex decisions with multiple criteria and alternatives (Baker et al., 2001).

2.4.3.3 Pros and Cons Analysis

Pros and cons analysis is a method that uses a qualitative comparison of all good and bad attributes. This method depends on comparing the pros and cons one for each alternative. It is suitable for a few alternatives involving a few criteria (Baker et al., 2001).

2.4.3.4 Cost Benefit Analysis (CBA)

Cost-benefit analysis depends on two criteria: financial costs and financial benefits. It is a quantitative method to assess the desirability of policies by taking a long view of future effects (MT, 2008). It is a powerful and easy tool for decision making.

2.4.3.5 Analytic Hierarchy Process (AHP)

AHP is designed to cope with the intuitive and rational to select the best alternative (Saaty and Vargas, 1994). It is a quantitative method to select a preferred alternative by pair-wise comparisons of the alternative's relative performance. It is a systematic procedure for representing the elements of a problem hierarchically, as shown in Figure 2.1. By breaking down a problem into its smaller parts, decision makers are guided through a series of pairwise comparisons of the relative impact of the elements in the hierarchy (Baker et al., 2001). Two factors of the same level can be compared to a

particular factor at an upper level. AHP can be used whenever a problem can be reduced to a hierarchical representation of at least two levels (Bertolini et al., 2004). AHP measures the consistency ratio (CR) to check the consistency of judgment (Saaty, 1990a). Figure 2.2 shows the AHP chart and the procedure can be summarized as follows (Saaty, 1994):

- Identification of the main goal, factors and alternatives.
- Construction of the hierarchical structure, from the top and down to the alternatives.
- Construction of pair-wise comparisons.
- Calculation of the priority vector for all the factors.
- Synthesize the results to determine an overall outcome.
- Analyze the sensitivity to change the judgments.

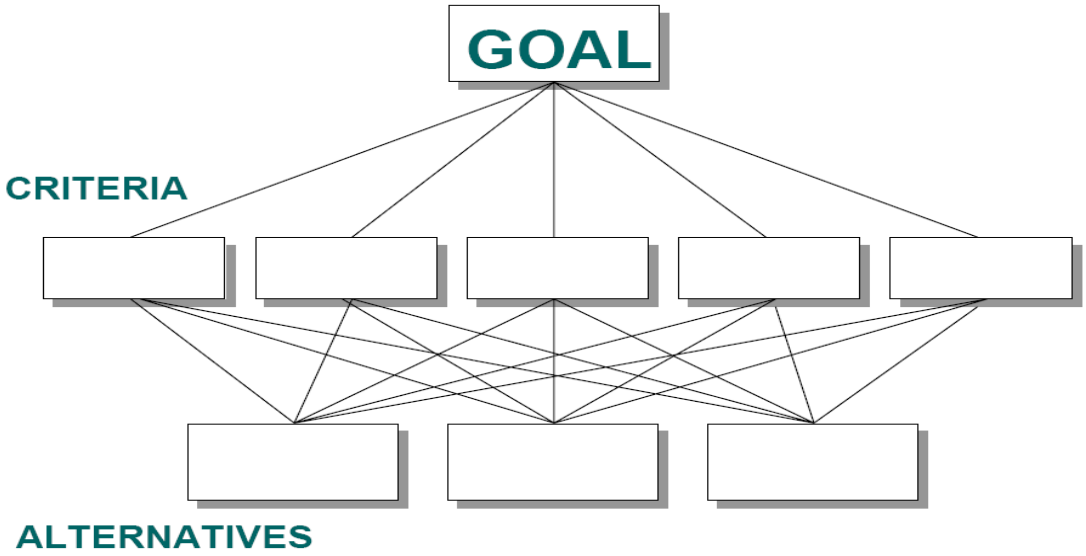


Figure 2.1: AHP Hierarchy

AHP Method Chart

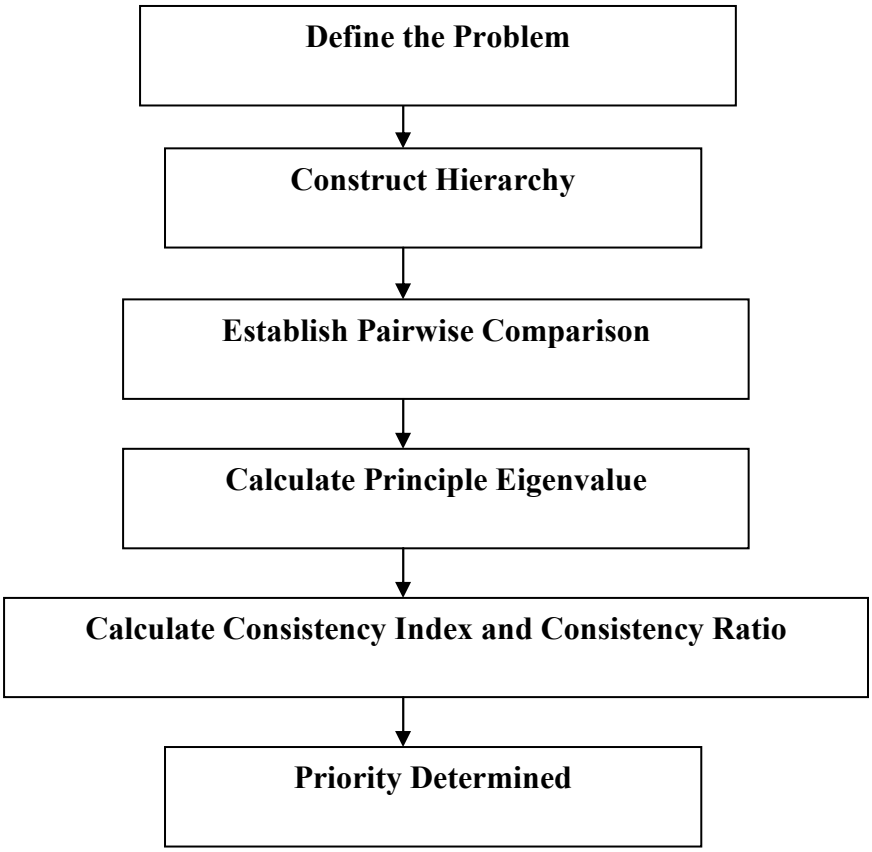


Figure 2.2: AHP Method Chart

2.4.3.5.1 AHP Features (Saaty, 1994)

- Taking judgments based on the feeling of people.
- Reciprocal comparison is used rather than assigning a subjective number.
- Breaking down the complex problems into hierarchic form.
- Integrating hard data with subjective judgments about intangible factors.
- It allows individuals to refine problems.
- It enables decision makers to perform a sensitivity analysis.

2.4.3.5.2 Structuring Hierarchies

The most influential step in decision-making is to structure a hierarchy and arrange the factors on its levels (Saaty, 1990b). Creating the hierarchy requires concern for the factors and sub-factors that directly influence the overall goal, as well as an ability to identify alternatives suitable for accomplishing the goal (Saaty and Vargas, 1994). The hierarchy must be designed so that these alternatives are precisely evaluated on their capability to assure the overall goal. The number of levels depends on the complexity of the problem and on the detail which the decision maker requires to solve the problem (Saaty, 1990b).

2.4.3.5.3 Pair-wise Comparison

AHP allows the user to concentrate on making a sound decision through comparing a pair of elements. Pair-wise comparisons give the user a basis on which to reveal preferences (Saaty, 1990b). The comparison moves from the top of the hierarchy down by the using scale 1-9 as shown in Table 2.2. At the bottom of the hierarchy, the

alternatives are then compared to the sub-criteria. The paired comparison criteria are listed as factors that influence the decision. Then, the importance of each factor is determined (Saaty, 1990a).

Table 2.2: Pairwise Comparison Scale (Saaty, 1990a)

Intensity of Importance	Definition
1	Equal importance of both elements
3	Weak importance of one element over another
5	Essential or strong importance of one element over another
7	Demonstrated importance of one element over another
9	Absolute importance of one element over another
2, 4, 6, 8	Intermediate values between two adjacent judgments

2.4.3.5.4 Analytic Hierarchy Process Principles

The application of AHP is based on the following four principles (Sahni, 2007; Zahedi, 1986):

1. The Hierarchy of Decision: A decision problem is decomposed into a hierarchy with each level consisting of a few elements.

2. Prioritization: involves pairwise comparisons of various elements at each level with respect to an element from the next level up.

3. Synthesis: aggregate the various levels into composite relative weights.

4. Sensitivity analysis: The stability of the outcome is determined by testing the best choice of the criteria.

2.4.3.6 Cumulative Voting (CV)

Cumulative Voting, an easy technique for prioritizing criteria, is based on distributing points between requirements. The group is provided with 100 points to distribute among criteria. The more the points awarded to a particular criterion, the higher is its priority. CV is easy when there are few criteria. However, when the number of criteria increases, the method starts losing its accuracy (Sahni, 2007).

2.4.4 Expert Choice Software (EC)

Expert Choice software is a multi-objective decision support tool, based on AHP (Saaty 1999a). It assists the user in all phases of the decision making, from model structure to final report output. It is used for creating a model, pairwise comparison assessments, and sensitivity analysis. Expert choice decision models follow the standard AHP format, a functional hierarchy with the broad overall goal or objective at the highest level. Lower levels correspond to the criteria and sub-criteria for choosing among alternatives (Saaty 1999b; Saaty, 1994).

2.4.4.1 Use of Expert Choice Software

Expert Choice is used for a variety of applications including: facilitating group decisions, analytical planning, resource allocation, formulating marketing strategy, selecting alternatives, evaluating acquisitions and mergers, innovation management, engineering design evaluations, production and operations management, policy formulation and evaluation, and human resource management (E.C., 2008).

2.4.4.2 Pairwise Comparisons in Expert Choice Software

Expert Choice uses pairwise comparisons to derive priorities which more accurately reflect the perceptions and values than any other way. Its three methods include: verbal judgment, numerical judgment, and graphical judgment (E.C., 2008).

2.4.4.3 Synthesis

Synthesis in the Expert Choice is the process of combining priorities throughout the model to get the final result. Priorities are obtained throughout the model by applying each node's local priority and its parent's global priority. The alternatives are summed to get overall priorities so that the most preferred alternative is the one with the highest priority. The software presents the priorities of the alternatives in the form of a bar graph. The best choice is the alternative with the longest bar (E.C., 2008).

2.4.4.4 Sensitivity

For sensitivity analyses, the software allows the user graphically to check the alternatives with respect to the importance of the objectives. It can be performed from the

top of hierarchy or from a selected node. In all cases, there must be at least two levels below the selected node (E.C., 2008). After making judgments about the relative importance of all factors, Expert Choice helps to test the sensitivity of the decision to changes in priorities.

CHAPTER THREE

FACTORS IN DECISIONS ON OUTSOURCING

3.1 Introduction

Outsourcing is an organization's chance to improve the available process in many aspects. However, outsourcing is not easy, and it needs to be well planned and organized (McIvor et al., 1997; Blumberg, 1998). Therefore, it is very important to assess and identify the factors that are involved before an organization decides to outsource some functions. In some cases, outsourcing could cost the organization more than the in-house resources; therefore a detail analysis should be performed (DiRomualdo and Gurboxani, 1998).

In the following paragraphs, the factors that influence the decision on outsourcing for maintenance services will be discussed.

3.2 Factors Influencing Outsourcing Decision

The relevant factors are discussed and classified in this chapter under six main categories: Strategic, Economic, Management, Technological, Function Characteristics, and Quality.

3.2.1 Strategic Factors

These factors enable an organization to acquire many benefits, regarding its long-term objectives such as focus on core activities, accelerate re-engineering, improve flexibility to the changing market dynamics, risk sharing with the contractors, lack of internal resources, and freeing resources for core activities. These factors should be discussed as follows:

3.2.1.1 Focus on Core Activities

By focusing on core activities, an organization can support its position for a competitive advantage. The decision on exactly what function is core should have bearing on whether or not to outsource them. Quinn (1999) suggests that "those activities, usually intellectually-based, that the company performs better than any other enterprise" are core. The most strategic factor influencing the outsourcing decision is to allow the organization to focus on its core activities (Sislian and Satir, 2000).

3.2.1.2 Access to World-Class Capabilities

Outsourcing providers bring world-class resources to meet the needs of their users. In principle, outsourcing can provide access to "best in the world" quality and competitive advantage. However, in the absence of fully developed monitoring, the quality may on occasion be illusory (Quinn, 1990).

3.2.1.3 Freeing Resources for Core Activities

When organizations outsource non-core services, internal resources can be redirected toward services that have a greater return and sustain the organization's main purposes (Quinn, 1999).

3.2.1.4 Accelerate Re-Engineering Benefits

Re-engineering is the search for a new method or process to reorganize the elements of work. It is sometimes defined as redesign of the current processes to achieve improvements in measures of performance, such as cost, quality, service, and speed (Lankford and Parsa, 1999). Outsourcing can be considered as one way to use the new process for improvements in the performance (Corbett, 1998). Outsourcing enables an organization to understand the expected benefits of re-engineering by engaging an outside contractor who is already re-engineered to world-class standard (Lau and Zhang, 2006).

3.2.1.5 Risk Sharing with Contractors

The risks include loss of control over quality and operation of services, loss of competitive advantage, loss of flexibility, and loss of security (Ketler, 1999). When organizations outsource some services to share risk, benefits are made by a service provider who is better able to estimate alternatives (Corbett, 1998). The service provider undertakes investments and shares the risks among many clients (Quinn, 1999).

3.2.1.6 Lack of Internal Resources for a Service

Organizations may be particularly impacted by a lack of resources. In such cases, the best alternative may be to acquire the needed resources from a contractor (Kremic, 2006). Access to the people with specialized skills may be an issue that affects the outsourcing decision. In general, a function is more likely to be outsourced if there is a lack of internal resources to perform it. Resources available from contractors can help for performing functions and controlling all aspects of these functions (Green, 2000).

3.2.1.7 Improve Flexibility to the Changing Market Dynamics

Flexibility, which is a strategic factor, includes operational flexibility, resource flexibility, and demand flexibility (Kremic, 2006). The potential for improved flexibility is measured by the organization's ability to change the service range in response to market conditions (Jennings, 2002). In today's quickly changing world, an organization has to respond quickly to changing customer demands. Outsourcing helps the organizations to be flexible by providing reliable workers to reduce the time needed to complete works (Djavanshir, 2005).

3.2.1.8 Strategic Alliance with Contractors

Alliance is a voluntary cooperative arrangement between two or more organizations to achieve mutually compatible goals that they could not achieve easily alone (Arino et al., 2001; Lambe et al., 2002). Organizations adopt alliances with contractors due to the growing pressure of competition and rapid technology change. Alliance may enable an organization to make up the shortage of resources or technology

because the contractors have a specialized experience in a particular field so that they can work more efficiently and effectively (Collins and Millen, 1995).

3.2.1.9 Regulations Governing the Outsourcing Practices

This factor affects the degree to which outsourcing complies with legal requirements and regulations govern the performance of a function in compliance with standards. The internal politics environment of an organization may also influence the outsourcing decision (Kremic, 2006).

3.2.2 Management Factors

All factors influencing the performance and management of services including design, control, and implement are considered as management factors. There are many management factors influencing the decision on outsourcing, such as increased speed in performance, a function difficult to manage, savings in management time, reducing the management load, etc.

3.2.2.1 Save the Management Time

Reducing the time needed to complete a job is an important objective for all organizations. Services may be performed by an outside contractor faster than in-house, because they have all the necessary tools and means. The internal management of an organization can focus on their core activities by giving the repetitive non-core activities to outside contractors (Batta, 2006; Djavanshir, 2005).

3.2.2.2 Reduce the Management Load

Outsourcing is a means to reduce the management and control time by reducing the workload and freeing management to focus on the core activity (Graham, 1996). Therefore, an organization should determine the services which an outside contractor can perform (Greaver, 1999; Blumberg, 1998).

3.2.2.3 Need for Specialized Management

Skills of contractor staff and high-level management have the most impact the decision on outsourcing. Greaver (1999) stated that a lack of specialized and skilled staff to manage the activities often forces organizations to seek another solution. It is assumed that contractors can manage and deliver that service perfectly because they have sufficient staff (Collins and Millen, 1995).

3.2.2.4 Increase the Speed of Implementation

Some services such as corrective maintenance need rapid responses to repair failures. Therefore, the speed of implementation is the important factor. Outsourcing enables an organization to put pressure on a contractor to respond to changes because the contractor should have the resources to perform a service in the agreed time (Greaver, 1999).

3.2.2.5 Function Difficult to Manage

If a service is complex or integrated, or if there is no qualified management staff, the organization may get appropriate equipment from service provider (Kremic, 2006; McDonagh and Hayward, 2000).

3.2.2.6 Safety Management

To avoid loss of life, personal injury, property damage, and to ensure safe and healthful conditions for persons, the use of skilled external management should reduce the exposure to legal liability for accidents that may be occurred in the work situations. All contractors must control hazards at the site where they perform a service by reviewing all safety rules, and by ensuring that all accidents will be investigated and eliminated (Marie, 1995).

3.2.2.7 Consolidation and Decentralization

Outsourcing is an effective way to gain flexibility in an organization or even in its departments. It increases the flexibility of organization through the better use of internal resources, including consolidation or decentralization (Quelin and Duhamel, 2003).

3.2.3 Technological Factors

These factors include the acquisition of new skills and technology, the need for specialized expertise, flexibility in technology, increased access to diverse technologies, innovative ideas, technical knowledge, and technology environment changes.

3.2.3.1 Achieve Flexibility with Changing Technology

The growth and change in all aspects of technology necessitates flexibility through constantly monitoring and developing the growth rate to remain competitive. If an organization cannot respond to a technological change, it should outsource the relevant functions (Batta, 2006).

3.2.3.2 Initiate Innovative Ideas and Techniques

If an outside contractor really wants to gain the confidence of an organization, the contractor should use his/her knowledge and technical experience to introduce innovative ideas in design and operation that improve the old process (Campbell, 1995; Quinn, 1999; Greaver, 1999).

3.2.3.3 Improve the Technology for Competitive Advantage

For developing and sustaining competitive advantage, organizations require access to appropriate technologies for improving their services (Jennings, 2002). Secondly, by use of technology for competitive advantage require a decision on whether the outsourced services would achieve this advantage (Greaver, 1999).

3.2.3.4 Technology Requirements Uncertainty

Uncertainty in the technological change and in expectations may hard the definition of the requirements. If the technological environment is highly uncertain, a service may be performed more easily by an external contractor (Kremic, 2006).

Blumberg (1998) stated that "technology is either very stable with limited applications or very dynamic, changing quicker than the rate of adaptation".

3.2.3.5 Need for Specialized Expertise

Specialist contractors can afford to advance in new technologies and innovative practices, because they perform only one service and have all the means to perform it. They can focus on identifying areas susceptible to improvement and on the knowledge needed to act successfully (Alexander, 1996; Batta, 2006).

3.2.3.6 Acquire New Skills or Technical Knowledge

Outsourcing may help an organization to gain new skill and knowledge so that it can afford to develop its expertise to maintain high-level technology. Therefore, when some services are outsourced, an organization should gain new skills or new technical knowledge from the outside supplier (Alexander, 1996; Probert, 1997; McDonagh and Hayward, 2000; Greaver, 1999).

3.2.4 Economic Factors

All organizations need to achieve the lowest cost consistent with their competitive strategy. An organization can save enough by outsourcing to perform a service for less than a competitor. Economic factors influencing the decision on outsourcing are: reduce the costs of development and maintenance, make the fixed costs into variable costs, improve the cash flow, improve the return on assets, and cash infusion.

3.2.4.1 Save the Overall Cost

The key driver for many outsourcing decisions is the reduction in the cost of labor, materials, and parts (Lindskog, 2005). The function is outsourced when the in-house costs are higher than the anticipated costs for outsourcing the function. Therefore, the higher the internal cost to perform the function relative to the anticipated cost of outsourcing, the greater the probability of outsourcing (Kremic, 2006).

3.2.4.2 Reduce the Labour and Operating Cost

Costs can be reduced, either by saving on labour costs or by using new technology for efficiency. Djavanshir (2005) stated that the best benefits of outsourcing are in reducing the labor and operating cost, and gaining a competitive advantage. The decrease in labour and operating costs is based on a contractor's experience to perform or provide a certain service more efficiently and effectively.

3.2.4.3 Make the Fixed Costs into Variable Costs

Outsourcing helps an organization to move fixed costs (such as payroll or labor productivity and materials) so that they become variable costs (Anderson, 1997). Costs for operating resources and investments of fixed infrastructure can be reduced step-by-step after the services have been outsourced. Then the payment to the contractor would convert the fixed costs into variable costs (Blumberg, 1998).

3.2.4.4 Improve the Cash Flow

An organization's cash flow is improving when it has fewer employees, and than it requires less infrastructure and support systems, which may result in greater efficiency by reducing variable cost and managed cost (Fontes, 2000). Some organizations outsource to achieve better cost control that improves the cash flow (Anderson, 1997). Outsourcing has the probability to be long-term if contractors can offer quality services more cost-effectively than in-house (Yik, 2005).

3.2.4.5 Cash Infusion

Outsourcing is desired when the costs offered by contractors are low enough than the added overhead and profit (Fontes, 2000). All tools, equipment, vehicles, and facilities used in the current operation have value if they improve cash infusion by being transferred to the contractors (Corbett, 1998).

3.2.4.6 Make Capital Funds more Available for Core Activities

Reducing the need to invest capital funds in non-core functions, and making them available for core areas, makes organizations sometimes consider outsourcing to increase flexibility in finance and to make capital funds more available for core activities (Djavanshir, 2005; Greaver, 1999).

3.2.4.7 Increase the Economic Efficiency

The motivation of outsourcing is sometimes economic, such as scale efficiency (Arino et al., 2001). Organizations that specialize in particular services make a relatively

large business volume, which allows them to take advantage of scale economies and thus to operate and maintain the services more cost-effectively (Quelin, 2003).

3.2.5 Quality Factors

Service quality includes quality planning, quality control, quality assurances, and quality improvement. If the organization's service quality is held in high regard, outsourcing the service should be seen as a potential improvement (Anderson, 1997). The quality factors influencing the decision to outsource services are: reach higher service level, improve service quality, meet special requirements, and achieve competitive advantage.

3.2.5.1 Improve Service Quality

Service quality appears to be an important factor regarding the scope of service. The quality of maintenance work is required to bring facilities and equipment to a condition that meets acceptable facilities maintenance standards. When some services are outsourced, the quality of services should be measured against the standards (Campbell, 1995; Hendrickson, 1998).

3.2.5.2 Improve Quality Requirements

The way to gain competition advantage is to outsource non-core activities for improving service requirements so that the outsourcing will help to compete with others. Maintenance requirements continuously change due to wear and tear, technological developments, and changing operational requirements. The quality requirements involve

statutory and regulatory compliance with minimum standards of material and implementation (Campbell, 1995; Hendrickson, 1998).

3.2.5.3 Achieve High Quality of Service for Competitive Advantage

When an organization is currently recognized for a high quality, there may be concern by decision makers that outsourcing might affect the quality of services (Kremic, 2006). Organizations need to react rapidly to user requirements, and so outsourcing is seen as a means to accomplish high competitive advantage. The availability of contractors encourages organizations to outsource their non-core activities. As a result, the quality of services is improved at a lower cost (Quinn, 2000; Campbell, 1995).

3.2.5.4 Procure Higher Reliability and Competency

The quality and reliability of processes and services may be improved by engaging a contractor based on past performance (AL-Najjar, 1996). Strategy for service quality needs to reflect the organization's position to develop competitive advantage and higher reliability through the services that it offers. The high quality of services establishes reliability and can generate satisfaction for users (Kremic, 2006).

3.2.6 Function Characteristics Factors

Some functions inherently better when outsourced (Kremic, 2006). This is due to such characteristics: complexity, and degree of integration, structure, lack of spare parts, and lack in equipment or tools.

3.2.6.1 Complexity of Function

Complexity of a function refers to the difficulty of understanding its variables and anticipating its specific outcome (Kremic, 2006). Outsourcing is the performing of a service under contract between two parties, assuming that they both want the service should be delivered (Prencipe, 1997).

3.2.6.2 Function Integration and Structure

Integration is related to the functions within the organization which are difficult to manage internally. The more integrated a service, the more interactions and communication there is to maintain and monitor that particular function (Kremic, 2006). The structure of a function impacts the decision to outsource it. A more structured function is a better candidate for outsourcing (Kremic, 2006).

3.2.6.3 Lack of Spare Parts

Spare parts are defined as all parts, equipment and expandable assets to operate a facility for a specified time (Mahmoud, 1994). Spare parts may also include non-expandable assets. Non-expandable assets are those that retain their identity during normal usage such as furniture, equipment, interior decoration, etc (Mahmoud, 1994).

3.2.6.4 Function Difficult to Control

Control of function includes organizing, performing, and evaluating work. If an organization cannot perform and control the service or function well in-house, it is advised to transfer it to qualified contactors. The degree to which preferences influence a

decision may be difficult to predict. Further, the influence may be hidden in supporting documents or ancillary decisions, and thus may be difficult to identify (Prencipe, 1997).

3.2.5.5 Lack in Equipment/Tools Availability

Equipment/Tools can be defined as any apparatus used in performing a service including mechanical, electrical and information. The main measure for any tool is whether it improves the performance of a task and it can be economically justified. Proper tools can reduce the time needed to accomplish a service (Patton, 1988).

CHAPTER FOUR

RESEARCH METHODOLOGY

4.1 Introduction

The main objective of this research is to assess the crucial factors influencing the decision to outsource maintenance, and develop a decision-making framework helping managers on whether to outsource or not. This chapter presents all steps performed to achieve the objectives of this research.

The first step was to acquire the overall knowledge through literature review to identify the facility systems/services requiring maintenance and the factors influencing the outsourcing decision.

The second step was to obtain a priority index by reviewing several methods. The AHP was utilized to obtain high level of accuracy, rank all factors of outsourcing decision and to develop a decision-making framework.

4.2 Literature Review

The review has emphasized on existing researches of maintenance services, outsourcing and more precisely the factors of outsourcing decision. The literature was collected through searches in databases by using key words: maintenance services, maintenance outsourcing, outsourcing decision, outsourcing motivational factors, and

outsourcing decision factors. The chosen literature includes: popular magazines, books, journals, and empirical studies.

4.2.1 Facility systems/services

In this phase, a comprehensive list of facility systems/services is developed to include: heating, ventilation and air conditioning systems, fire protecting systems, elevator systems, plumbing and sanitary systems, electrical systems, painting (interior and exterior of buildings, major construction and renovation works, minor construction, carpentry, steel work, telecommunication systems, electrical appliances, housekeeping and waste disposal and landscaping services.

4.2.2 Factors of Outsourcing Decision

The literature review resulted in collecting a comprehensive list of forty-four factors identified by various researches was developed and classified under six main categories: strategic, management, economic, technological, quality, and function characteristics.

4.3 Preliminary Interview

The purpose of this phase was to explain the research's objective to the participants and seeking their interest. Brief definitions of the factors were developed and taken to the interviews, to make them understand better. Face-to-face interviews were conducted with two maintenance managers at King Fahd University of Petroleum and

Minerals, and King Faisal University, to ensure that the identified factors are clear, including all factors.

4.4 Pilot-Testing for Identified Factors

After the literature review and preliminary interview were conducted, the most factors influencing the outsourcing decision of maintenance services were developed. For a pilot study, two maintenance managers were interviewed and this helped in further simplification. As a result, the factors were reduced to thirty-eight factors grouped in six categories as shown in Table 4.1.

Table 4.1: The Outsourcing Decision Factors Considered in this Study

Categories	Related Decision Factors
Strategic	Focus on core activities (ODF#1), access to world-class capabilities (ODF#2), freeing resources for core activities (ODF#3), accelerate re-engineering benefits (ODF#4), risk sharing with contractors (ODF#5), lack of internal resources for a service (ODF#6), improve flexibility to meet the changing market dynamics (ODF#7), strategic alliance with contractors (ODF#8), and regulations governing the outsourcing practices (ODF#9).
Management	Save the management time (ODF#10), reduce the management load (ODF#11), need for specialized management (ODF#12), increase the speed of implementation (ODF#13), function difficult to manage (ODF#14), safety management (ODF#15), and consolidation and decentralization (ODF#16).
Technological	Achieve flexibility with changing technology (ODF#17), initiate innovative ideas and techniques (ODF#18), improve the technology for competitive advantage (ODF#19), technology requirements uncertainty (ODF#20), need for specialized expertise (ODF#21), and acquire new skills or technical knowledge (ODF#22).
Economic	Save the overall cost (ODF#23), reduce the labour and operating cost (ODF#24), make the fixed costs into variable costs (ODF#25), improve the cash flow (ODF#26), cash infusion (ODF#27), make capital funds more available for core activities (ODF#28), and increase the economic efficiency (ODF#29).
Quality	Improve service quality (ODF#30), improve quality requirements (ODF#31), achieve high quality of service for competitive advantage (ODF#32), and procure higher reliability and competency (ODF#33).
Function Characteristics	Complexity of function (ODF#34), function integration and structure (ODF#35), lack of spare parts (ODF#36), function difficult to control (ODF#37), and lack in equipment/tools availability (ODF#38).

4.5 Questionnaires Design

The questionnaires were used to obtain the data from the maintenance managers dealing with the outsourcing decision. The questionnaires were designed to be simple, and understandable. They were arranged into two types in addition to an introduction page explaining the objectives of questionnaire and the interest of this research.

- **Frequency of Outsourcing Maintenance Services**

This type was to identify the frequency of outsourcing the maintenance services to specialty contractors. The frequency rating has the following scale: Always; Often; Sometimes; Seldom and Never (see Appendix I).

- **Factors Influencing the Outsourcing Decision**

This type includes two parts: first part covers general information about the participants being asked (see Appendix II and III). The followings are general questions:

- Name (Optional)
- University Name
- Telephone No
- E-Mail Address
- Years of Experience
- Respondent Position
- The ratio between the cost of contracts and the overall cost of maintenance.

The second part consists of the information needed for achieving the objectives of this research (see Appendix I and II). The questionnaire contains thirty-eight short

questions in the first section by using scale 1-9, and then thirty-eight questions by using scale 1-9 in the right side Outsource and the left side Not-Outsource.

4.6 AHP Sample Size

Questionnaire surveys were distributed to maintenance department managers in eleven Saudi universities. The small sample size is mainly attributed to this reason, the selected universities have years of experience on maintenance services management, and others universities are newly established. In order to secure good quality data, a brief presentation with regard to the topic and methodology of the research was made to every respondent individually.

4.7 Data Analysis

4.7.1 Statistical Analysis Method

It is utilized to analyze the first type of the surveys. The weighted mean and standard deviation was calculated. The mean is the average of the values, obtained by summing the values and dividing by a number of values. The standard deviation is essential for assessing the degree of dispersion of the values around its mean. Then, the severity index was calculated by following equation (Al-Hazmi, 1987):

$$(I) = \left(\frac{\sum_{i=0}^{4} a_i x_i}{4 \sum_{i=0}^{4} X_i} \right) (100\%)$$

4.7.2 Analytic Hierarchy Process (AHP)

AHP, adopted to analyze the second and third type of the surveys, aims to quantify relative priorities for a given set of qualifying factors on a ratio scale. AHP is to put tasks into hierarchy and then compare them to find out the ratio of comparative importance among each decision factor. AHP involves four steps (Saaty, 1990a):

1. Breaking down the decision into a hierarchy of factors at the top level located the goal and at the last level located the alternatives.
2. Performing pairwise comparisons of all levels.
3. Estimating the weights of the decision factors by using eigenvalue.
4. Aggregating the relative weights of the decision factors.

4.7.2.1 Constructing Hierarchy

Once the decision factors are selected, they are arranged in a hierarchic structure downward from an overall goal to alternatives. Structuring the decision into hierarchy serves two goals. First, it provides an overall view of the complex relationship of variables inherent in the decision. Secondly, it helps the decision maker in making judgment on comparison of elements (Saaty, 1990b). The number of elements at each level of the hierarchy is limited to nine elements (Zahedi, 1986). At the top of the hierarchy lies the most objective of the decision. The last level of the hierarchy contains decision alternatives (Aljaroudi, 1998).

4.7.2.2 Structuring the Decision Model

When the AHP model is constructed, the first step is to identify the factors. The computer software (Expert Choice) and the factors were used to develop the model. The model name is outsourcing decision factors located at level 0 of the model. The main factors had been classified into six categories, were inserted in level 1 of the model. Each category factors were inserted in level 2 of the model. Finally, outsource and not-to outsource decisions were inserted below the hierarchy leaves to serve as the choice alternatives. Figure 4.1 shows the model of outsourcing decision factors.

4.7.2.2.1 Strategic Factors Node

It is broken down into nine sub-factors in the next level, level number two as shown in Figure 4.2. These are: focus on core activities, access to world-class capabilities, freeing resources for core activities, accelerate re-engineering benefits, risk sharing with contractors, lack of internal resources for a service, improve flexibility to the changing market dynamics, strategic alliance with contractors, and regulations governing the outsourcing practices.

4.7.2.2.2 Management Factors Node

It is broken into seven sub-factors as shown in Figure 4.3. These are: save the management time, reduce the management load, need for specialized management, increase the speed of implementation, function difficult to manage, safety management, and consolidation or decentralization.

4.7.2.2.3 Technological Factors Node

It is broken into six sub-factors as shown in Figure 4.4. These are: achieve flexibility with changing technology, initiate innovative ideas and techniques, improve the technology for competitive advantage, technology requirements uncertainty, need for specialized expertise, and acquire new skills or technical knowledge.

4.7.2.2.4 Economic Factors Node

It is broken into seven sub-factors as shown in Figure 4.5. These are: save the overall cost, reduce the labour and operating cost, make the fixed costs into variable costs, improve the cash flow, cash infusion, make capital funds more available for core activities, and increase the economic efficiency.

4.7.2.2.5 Quality Factors Node

It is broken into four sub-factors as shown in Figure 4.6. These are: improve service quality, improve quality requirements, achieve high quality of service for competitive advantage, and procure higher reliability and competency.

4.7.2.2.6 Function Characteristics Factors Node

It is broken into five sub-factors as shown in Figure 4.7. These are: complexity of function, function integration and structure, lack of spare parts, function difficult to control, and lack in equipment/tools availability.

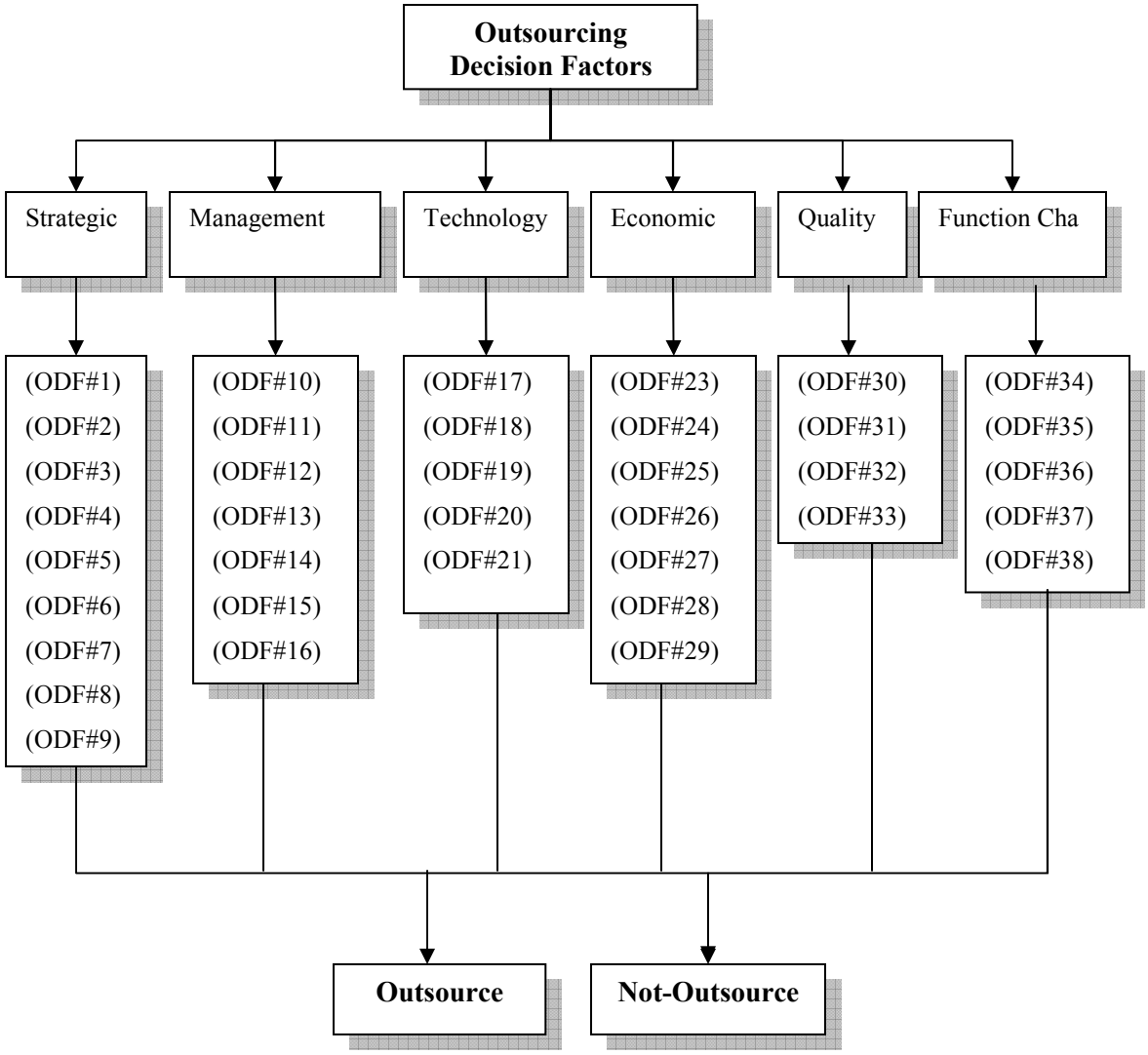


Figure 4.1: Model of Outsourcing Decision Factors

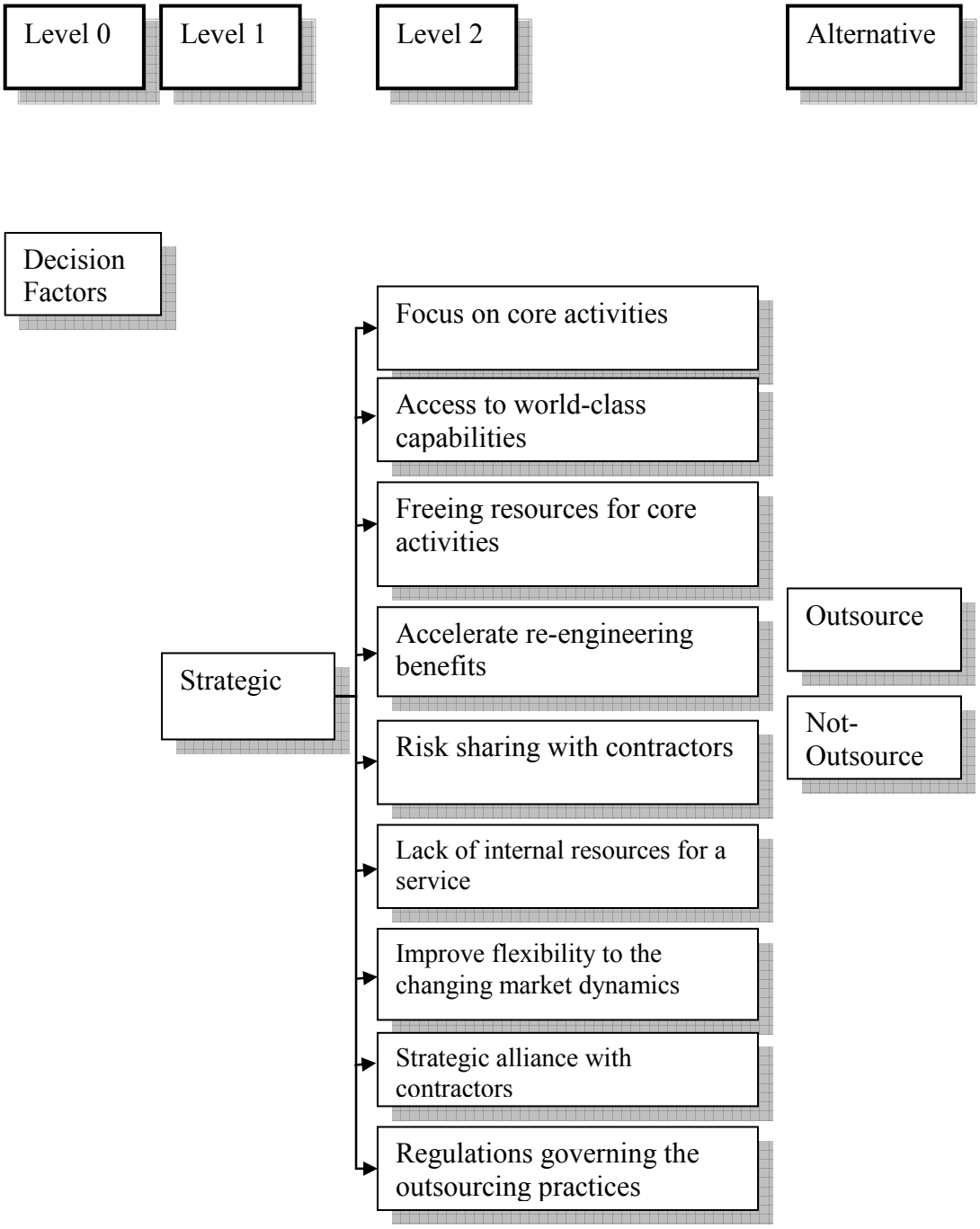


Figure 4.2: Model of Strategic Factors Node

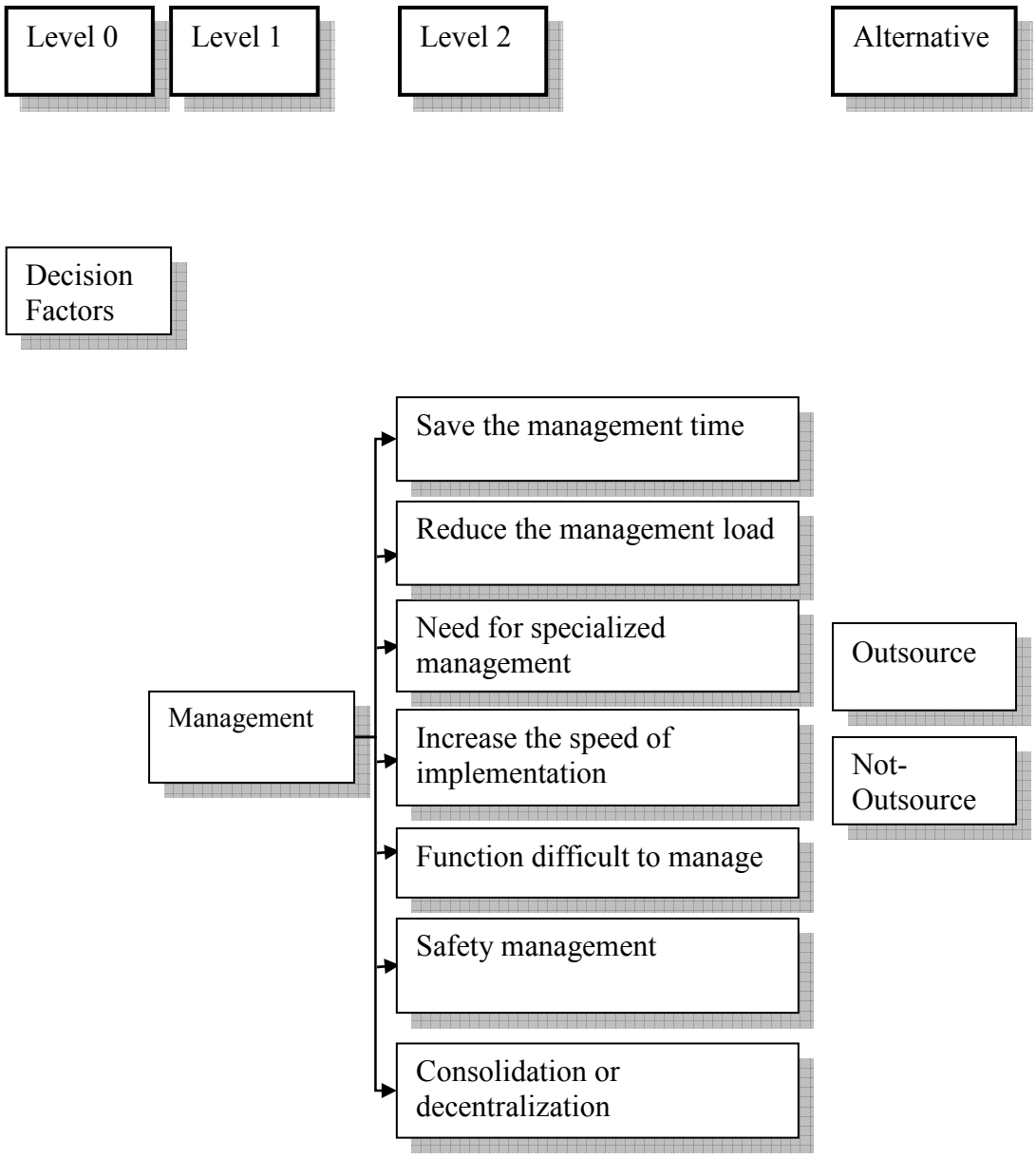


Figure 4.3: Model of Management Factors Node

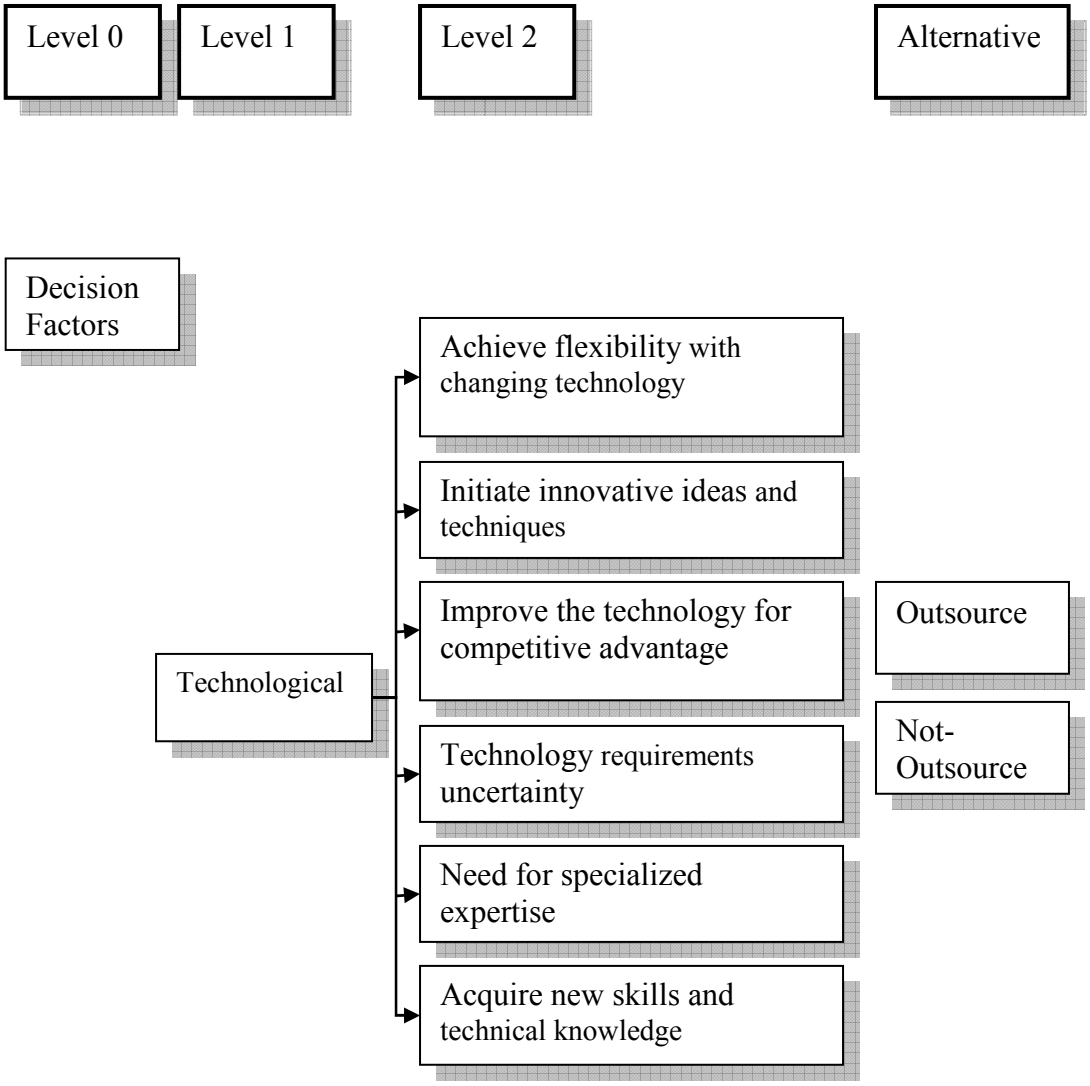


Figure 4.4: Model of Technological Factors Node

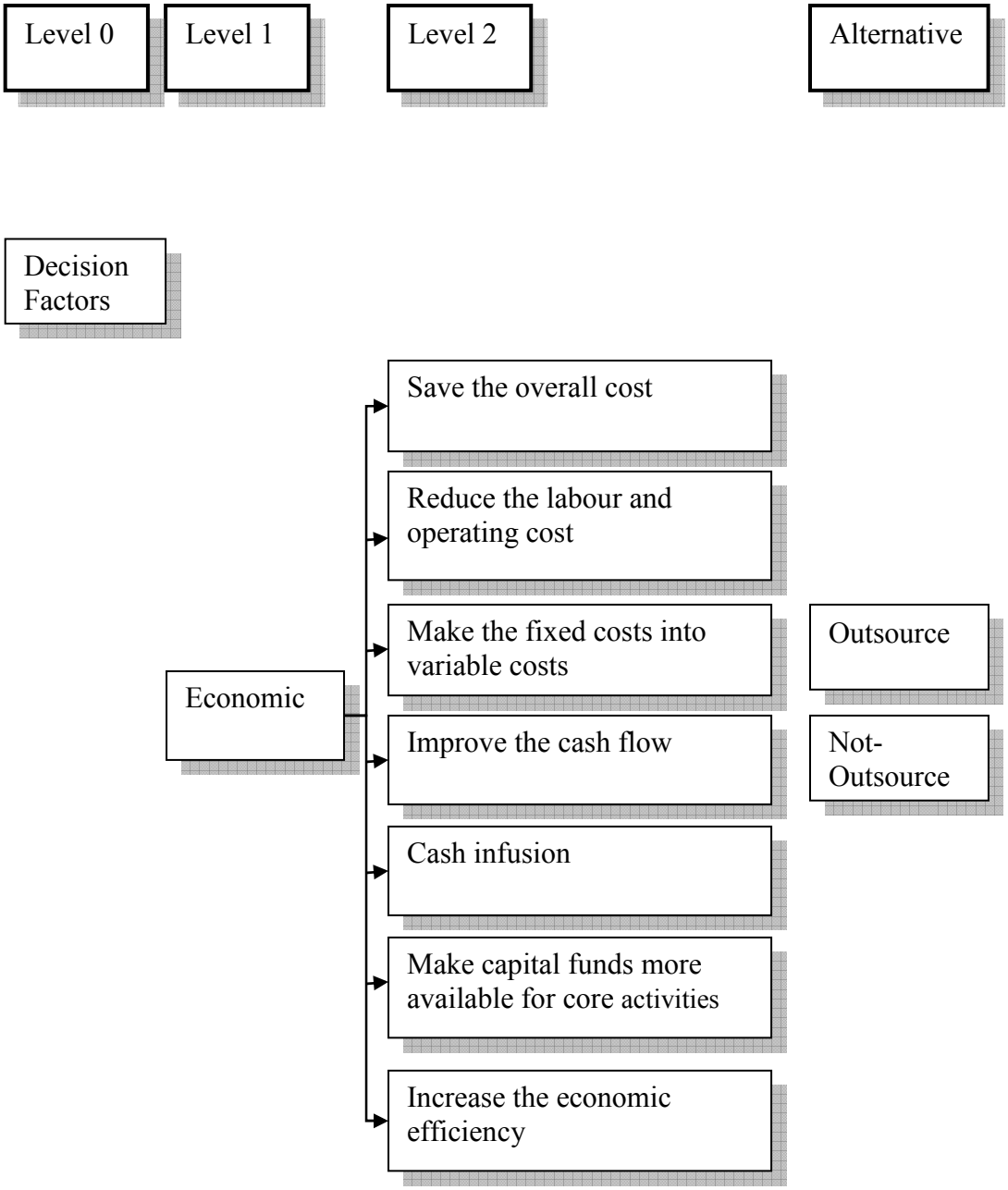


Figure 4.5: Model of Economic Factors Node

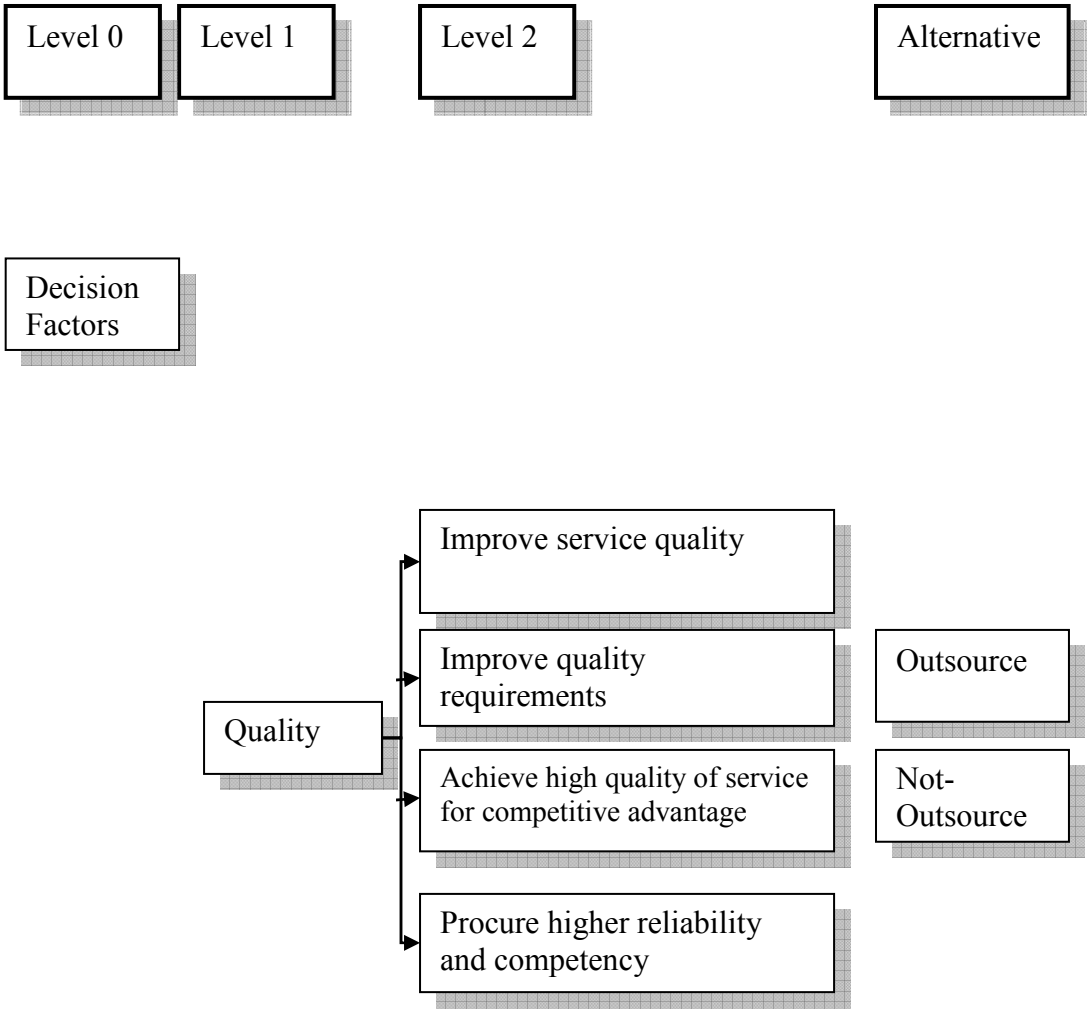


Figure 4.6: Model of Quality Factors Node

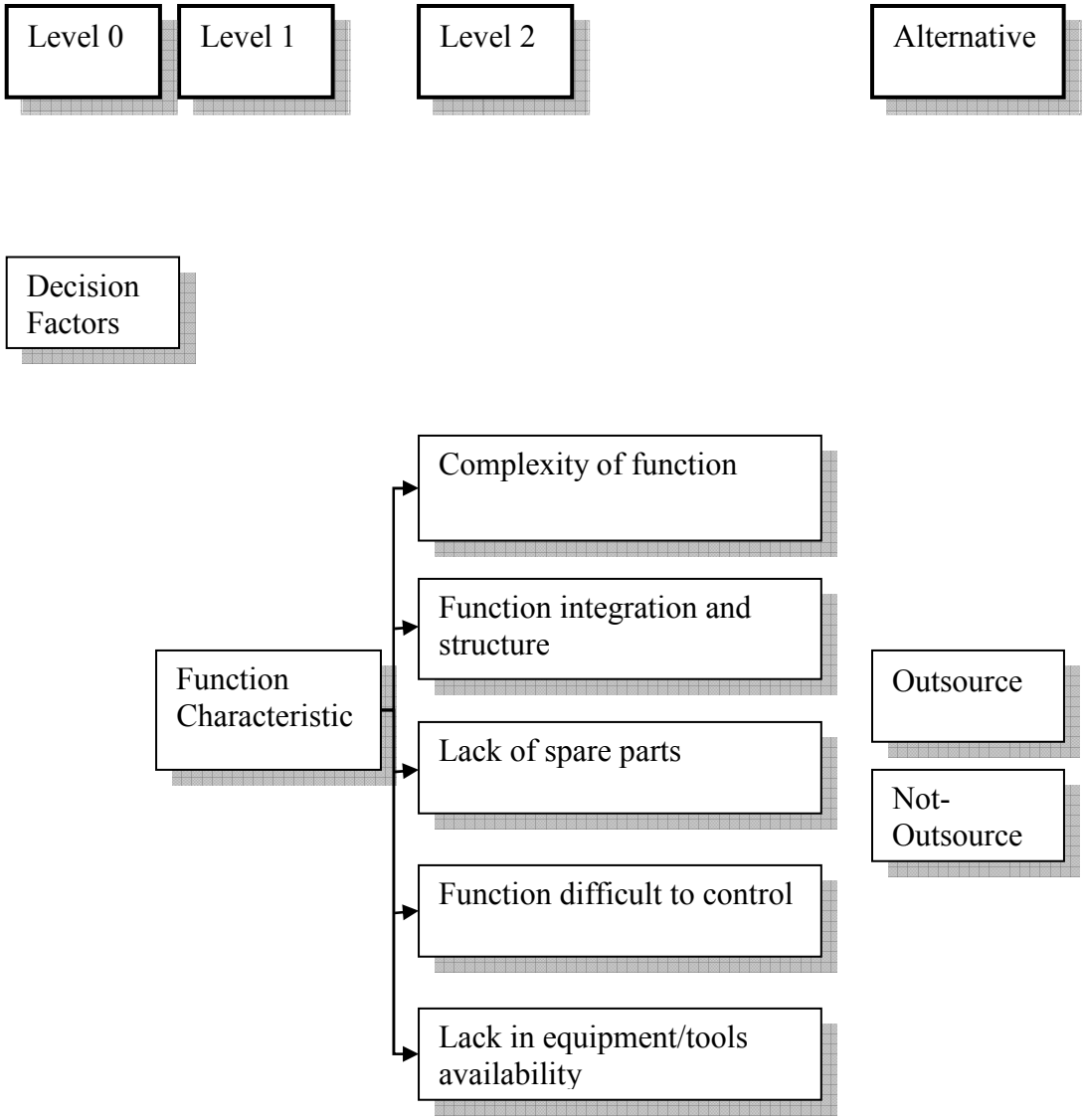


Figure 4.7: Model of Function Characteristics Factors Node

4.7.2.3 Pairwise Comparison

Once the model is built, the next step is to evaluate the factors. A pairwise comparison is the process of comparing the relative importance, preference, or likelihood of two factors with respect to another factor. AHP uses two types of measurement: relative measurement and absolute measurement. In relative measurement, paired comparisons are performed throughout the hierarchy, including the alternatives with respect to level above. In absolute measurement, paired comparisons are also performed through hierarchy with the exceptions of the alternatives (Saaty, 1990b).

In this research the relative measurement is used to decide how much various factors are rated relative to each other and how much this level influences the factors of next higher level, so that the relative strength of the impact of the factors in the lower level on the overall hierarchy can be calculated (Saaty, 1990a). A scale 1, 2, 3...., 9 is used to quantify how much important of each factor. The value 1 for instance means equally important and 9 means much more important. If the factor is less important than another one, then the inverse preferences 1, 1/2, 1/3,..., 1/9 are used. The 1 to 9 scales used is tabulated in Table 4.2.

When a set of n attributes is compared in pairs according to their relative weights. As shown in Table 4.3, the left entry of the matrix represents the factors being compared and denoted by Fl, F2, F3,… , Fn, and their weights represented by wf1, wf2, wf3,…. wfn. Rows represent the ratios of the weights of each factor with respect to all others. The matrix satisfies the reciprocal property. Thus, reciprocals of the judgments are

obtained by reversing the comparison. For example, when Fl scores 4 in the level of importance with F2, then F2 receives 1/4 when compared with Fl.

Table 4.2: Pairwise Comparison Scale

Scale Points	Description
9	Absolutely important
7	Very strongly important
5	Strongly important
3	Weakly important
1	Less important
2,4,6,8	Intermediate values

Table 4.3: Simple Matrix of Pairwise Comparisons

Factors	**F1**	**F2**	**F3**	→	**Fn**
F1	Wf1/wf1	wf1/wf2	wf1/wf3		Wf1/wfn
F2	Wf2/wf1	wf2/wf2	wf2/wf3		Wf2/wfn
F3	Wf3/wf1	wf3/wf2	wf3/wf3		Wf3/wfn
↓					
Fn	Wfn/wf1	Wfn/wf2	Wfn/wf3		Wfn/wfn

4.7.2.4 Establishing Priorities

When there are n factors (F1, F2 ... Fn factors). The quantified judgements on pairs of factors Fi, Fj are represented. It is called A matrix.

A = (aij), (i, j= 1, 2,….n).

If aij = x then aji = 1/x

$$\mathbf{A} = \begin{bmatrix} 1 & 1/a_{21} & 1/a_{31} & 1/a_{41} \\ a_{21} & 1 & 1/a_{32} & 1/a_{42} \\ a_{31} & a_{32} & 1 & 1/a_{43} \\ a_{41} & a_{42} & a_{43} & 1 \end{bmatrix}$$

After entering the judgements on pairs (Fi, Fj) as entries (aij) in matrix A, then assign weights W1, W2,……, Wn. Then there are steps should be followed (Al-Jaroudi, 1998):

1. Let F1 = 4, F2 = 2, F1/F2 = 2. The judgement would be F1 is twice F2. Thus, the relation between W, and the judgements (aij) is given by:

   wi / wj = aij (i,j = 1, 2, …….n)

2. Sum the values in each column of the pairwise comparison matrix and divide each factor in the pairwise comparison matrix by its column sum; the resulting matrix is called normalized pairwise comparison matrix.

3. Compute the average of the factors in each row of the normalized matrix. These averages provide relative importance of each alternative.

4.7.2.5 Consistency

AHP measures the consistency of a decision, and allows for revisions of the decision to reach an acceptable level of consistency by using Consistency Ratio (CR). If the value of this ratio is 0.1 or less, the decision is acceptable and suitable. When the value exceeds 0.1, the judgment may be random and should be revised (Saaty, 1990). The largest eigenvalue λ of a reciprocal matrix A is always greater than or equal to n. When the pairwise comparisons do not include any inconsistencies, the eigenvalue is $\lambda = n$ (Saaty, 1990a). The eigenvalue is calculated by multiplying each entry of the pair-wise comparison matrix by the relative priority corresponding to the column, and totaling the row entries. Then, the row totals are divided by the corresponding entry from the priority vector for calculating CR. Finally, the average is the eigenvalue. There are steps to calculate CR (Saaty, 1990a):

Phase 1: Multiply each value in the first column of the pairwise comparison matrix by corresponding relative priority matrix and repeat this phase for remaining columns.

Phase 2: Add the vectors resulted from Phase 1.

Phase 3: Divide each elements of the vector of weighed sums obtained by the corresponding priority value.

Phase 4: Compute the average of the values found. Let λ be the average.

$$\mathbf{A\ w = \lambda max\ w}$$

Phase 5: Compute the consistency index (CI) using this formula:

$$\mathbf{CI= (\lambda\ max - n)/(n-1)}$$

The CI is then divided by its random index (RI) to get the consistency ratio, which is a measure of how much variation is allowed. A Consistency Ratio (CR) is given by:

$$\mathbf{CR=100(CI/RI)}$$

If CI/RI < 0.10, the degree of consistency is satisfactory, but if CI/RI > 0.10, serious inconsistencies may exist, and the AHP may not yield meaningful results (Saaty, 1990a).

4.7.2.6 Sensitivity Analysis

It investigates how sensitive the rankings of the factors/alternatives are to changes in the importance. This is a particularly important aspect of an AHP analysis, since results are based on subjective expert assessments (Saaty, 1990a). Sensitivity analysis can be performed from any level; the software displays the sensitivity of alternatives to priority changes of the factors immediately below a user-selected node. The user can easily control the priorities and immediately see the impact of the change as reflected in the ranking of alternatives.

CHAPTER FIVE

DATA ANALYSIS AND RESULTS

5.1 Introduction

This chapter analyzes the results of the survey conducted. It presents the frequency of outsourcing for maintenance services to specialty contractors, the definition of the most important factors influencing the outsourcing decision, and discussion of the results obtained.

5.2 Questionnaire Surveys

The purpose of the conducting questionnaires was to collect data needed. To achieve this, the surveys design to include two types of questionnaires: identifying frequency of building system/services and assessing the importance of identified factors. The questionnaire surveys were distributed to the maintenance department managers of eleven universities in various regions of Saudi Arabia as shown in Table 5.1. The participants, who contributed in this research, constitute a mixture of maintenance department managers, and maintenance engineers who deal directly with all aspects of the outsourcing process.

Table 5.1: List of Participated Universities in this Research

No	University
1	Umm Al-Qura University
2	King Abdul Aziz University
3	King Fahd University of Petroleum and Minerals
4	King Faisal University
5	King Saud University
6	King Khalid University
7	Imam Muhammad bin Saud Islamic University
8	Taif University
9	Qasim University
10	Najran University
11	Islamic University of Medina

5.2.1 Frequently Outsourced Maintenance Services

The facility systems/services requiring maintenance activities during their service life are identified as follows: heating, ventilation and air conditioning systems, fire protecting systems, elevator systems, plumbing and sanitary systems, electrical systems, painting (interior and exterior of buildings, major construction and renovation works, minor construction, carpentry, steel work, telecommunication systems, electrical appliances, housekeeping and waste disposal and landscaping services.

The data collected from questionnaire respondents, was analyzed statistically to calculate the mean, frequency and standard deviation of the maintenance services and then ranked according to the highest average and represented the percentage (Always: 75-100; Often: 50-75; Sometimes: 25-50; Seldom: 0-25 and Never: 0) as shown in Table 5.2. The results show that Saudi universities evaluated the frequency of maintenance services required outsourcing as follows: fire protection systems and elevator systems obtained the highest percentage and the minor construction obtained the lowest percentage. The participants then asked to add any activities/services to be outsourced, so some of them write plant, faxes and copiers and give them always. Figure 5.1 shows the frequency of outsourcing of maintenance services in Saudi universities.

Table 5.2: Frequency of Outsourcing of Maintenance Services in Saudi Universities

Typical Maintenance Activities	4 Always	3 Often	2 Sometime	1 Seldom	0 Never	Frequency	Standard Deviation	Frequency (severity index) 100%	Rank
HVAC Systems	8	1	1	1	0	3.45	0.54	**86**	**2**
Fire Protection Systems	9	0	1	1	0	3.54	0.53	**88.5**	**1**
Elevator Systems	8	2	0	1	0	3.54	0.48	**88.5**	**1**
Plumbing and Sanitary Systems	6	3	0	2	0	3.2	0.63	**80**	**5**
Electrical Systems	7	2	0	1	1	3.3	0.5	**82.5**	**3**
Painting	6	1	3	1	0	3.1	0.63	**77.5**	**6**
Major Construction & Renovation Works	7	1	1	2	0	3.2	0.53	**80**	**5**
Minor Construction	4	0	1	2	4	1.8	1.12	**45**	**10**
Carpentry	3	2	4	2	1	2.54	0.68	**63.5**	**9**
Steel work	5	2	2	1	2	2.82	0.63	**70.5**	**8**
Telecommunication Systems	4	5	1	1	0	3.1	0.52	**77.5**	**6**
Electrical Appliances	5	4	1	1	0	3.2	0.53	**80**	**5**
Housekeeping and Waste Disposal	7	2	0	2	0	3.27	0.5	**81.7**	**4**
Landscaping Services	6	1	1	3	0	2.91	0.78	**72.5**	**7**

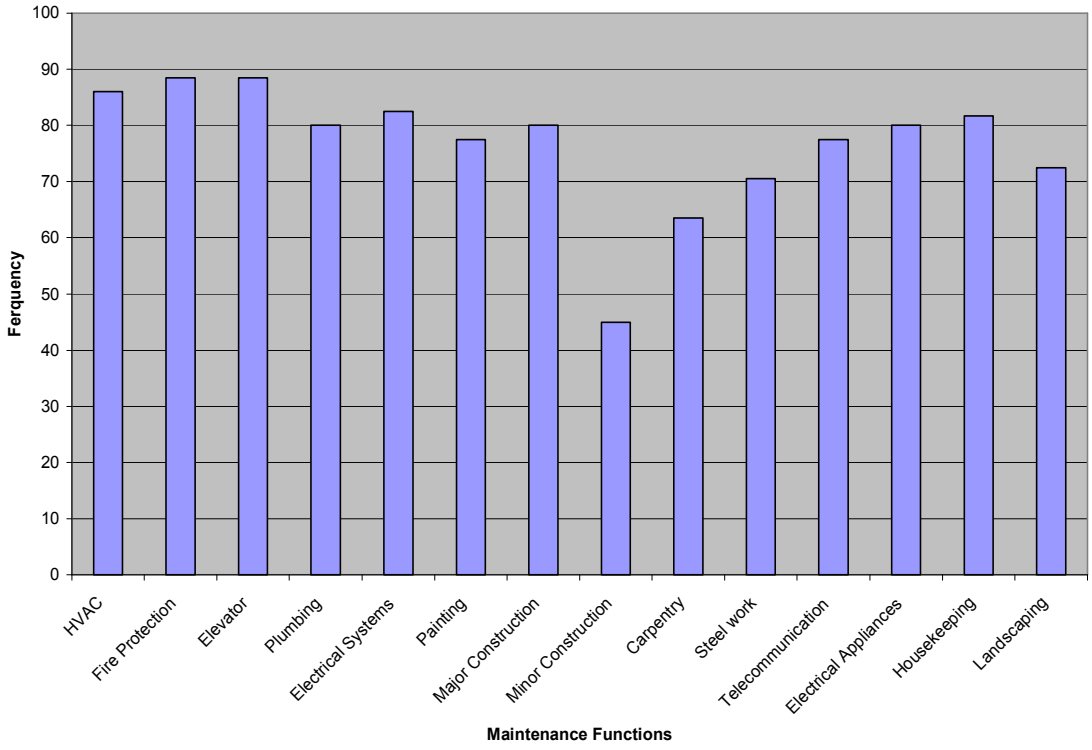


Figure 5.1: Frequency of Outsourcing of Maintenance Services in Saudi Universities

5.2.2 Assessing the Outsourcing Decision Factors

5.2.2.1 General Information

This section presents the general information on the respondents who answered the questionnaires (see Appendix II and III). The first part of the questionnaire started by asking the participants on their position, the experience that they have in this field, and the ratio of the costs of maintenance contract to the overall costs of the maintenance services. Table 5.3 shows the list of the participants with the general information.

After the analysis of the first part, the respondents were given the option of writing their names. It was noted from completed questionnaires that most of them mention their names.

This study considers the experience of the respondents. The years of experience were classified into four categories: less than five years, five to ten years, ten to twenty years, more than twenty years. It was found that 18% of them had over 20 years experience, 18% of them had 10-20 years experience, 27% of them had 5-10 years experience, and 37% of them had less than 5 years experience.

For the participant's position, 73% of them were working as Maintenance Managers, 9% of them were working as Enterprises Managers, and 18% of them were working as Maintenance Management Managers.

The ratio between the costs of outsourcing contract to the overall costs of maintenance was found that more than 36% of the universities contract out by value over 75% of cost, 19% contract out by 50-75% of cost, more than 36% contract out about 25-50%, and 9% of them contract out less than 25% of costs.

Table 5.3: List of Participants with General Information

University	Respondent Position	Years of Experience	Outsourcing Cost %
Umm Al-Qura University	Maintenance Management Manager	5-10 years	Over 75 %
King Abdul Aziz University	Maintenance Manager	5-10 years	Over 75 %
King Fahd University	Maintenance Management Manager	10-20 years	25-50 %
King Faisal University	Maintenance Manager	Less than 5 years	25-50 %
King Saud University	Maintenance Manager	Over 20 years	50-75 %
King Khalid University	Maintenance Manager	5-10 years	25-50 %
Imam Muhammad bin Saud Islamic	Maintenance Manager	Over 20 years	50-75 %
Taif University	Maintenance Manager	Less than 5 years	25-50 %
Qasim University	Maintenance Manager	Less than 5 years	Over 75 %
Najran University	Maintenance Manager	Less than 5 years	Over 75 %
Islamic University of Medina	Enterprises Manager	10-20 years	Less than 25 %

5.2.2.2 Technical Information

In the second part of the questionnaire, each participant was asked to review the list of factors and determine if there was any factor that needed to be added or deleted. Then, each participant was asked to determine the influence of each factor on the overall decision by assigning a number that represented the influence on a scale of 1 to 9 (see Appendix II and III).

5.2.2.3 Statistical Measures

Statistical analyze was performed to calculate the mean, the variance and standard deviation to the data obtained. Example: The standard deviation for the following values (7, 8, 8, 9, 8, 2, 7, 9, 7, 5, and 8) is shown in Table 5.4.

$$\text{Mean} = 78 \div 11 = 7.1$$

Table 5.4: Calculation of Standard Deviation

	1	2	3	4	5	6	7	8	9	10	11	**Sum**
Values	7	8	8	9	8	2	7	9	7	5	8	78
Deviation	-.1	0.9	0.9	1.9	0.9	-5	-.1	1.9	-.1	-2	0.9	0
Dev. Squared	.01	.81	.81	3.6	.81	25	.01	3.6	.01	4	.81	39.5

- Sum of the deviations squared = 39.5
- The variance = 39.5 ÷ 11 = 3.6
- Standard deviation = √39.5= 1.9

After analyzing the data, it was found that the average of the strategic category's importance was 7.1, and the standard deviation was 2.01. The average of the management category's importance was 7.0, and the standard deviation was 1.1. The average of the technological category's importance was 6.5, and the standard deviation was 1.9. The average of the economic category's importance was 7.2, and the standard deviation was 1.7. The average of the quality category's importance was 7.7, and the standard deviation was 1.35. The average of the function characteristics category's importance was 7.0, and the standard deviation was 1.9. This shows that service quality is the most important category followed by economic category. Tables (5.5-5.10) show the mean influence, the variance, and standard deviation of the decision factors that were resulted from the survey. Table (5.11) shows the mean influence of outsourcing decision categories. Tables (5.12-5.13) show the mean influence of outsourcing decision alternatives that resulted from the survey.

Table 5.5: Strategic Factors and Sub-Factors List with Mean Influence

Decision Factors	1	2	3	4	5	6	7	8	9	Total	Mean Influence	Variance	Standard Deviation
Strategic													
(ODF#1)	**1**	**0**	**2**	**0**	**0**	**0**	**0**	**1**	**7**	**78**	**7.1**	**4.1**	**2.01**
(ODF#2)	**0**	**0**	**0**	**1**	**1**	**0**	**2**	**4**	**3**	**82**	**7.45**	**2.67**	**1.6**
(ODF#3)	**0**	**1**	**1**	**0**	**2**	**1**	**2**	**1**	**3**	**70**	**6.36**	**5.85**	**2.4**
(ODF#4)	**0**	**0**	**1**	**0**	**5**	**0**	**3**	**1**	**1**	**66**	**6.0**	**3.0**	**1.7**
(ODF#5)	**0**	**0**	**0**	**0**	**1**	**1**	**2**	**3**	**4**	**85**	**7.73**	**2.45**	**1.57**
(ODF#6)	**0**	**0**	**0**	**2**	**1**	**2**	**3**	**1**	**2**	**72**	**6.55**	**3.1**	**1.75**
(ODF#7)	**0**	**0**	**0**	**0**	**1**	**1**	**2**	**5**	**2**	**83**	**7.55**	**1.47**	**1.2**
(ODF#8)	**0**	**0**	**1**	**0**	**1**	**0**	**3**	**2**	**4**	**81**	**7.36**	**3.65**	**1.9**
(ODF#9)	**1**	**0**	**1**	**1**	**1**	**3**	**1**	**2**	**1**	**63**	**5.73**	**5.6**	**2.37**
Composite Values											**6.87**	**3.54**	**1.83**

Table 5.6: Management Factors and Sub-Factors List with Mean Influence

Decision Factors	1	2	3	4	5	6	7	8	9	Total	Mean Influence	Variance	Standard Deviation
Management													
(ODF#10)	**0**	**0**	**0**	**0**	**2**	**0**	**3**	**2**	**4**	**83**	**7.55**	**2.27**	**1.5**
(ODF#11)	**0**	**0**	**0**	**1**	**2**	**1**	**2**	**4**	**1**	**75**	**6.82**	**2.56**	**1.6**
(ODF#12)	**0**	**0**	**1**	**1**	**0**	**0**	**1**	**5**	**3**	**81**	**7.36**	**4.0**	**2.0**
(ODF#13)	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**4**	**4**	**88**	**8.0**	**1.0**	**1.0**
(ODF#14)	**0**	**0**	**3**	**1**	**2**	**1**	**1**	**1**	**2**	**62**	**5.64**	**5.45**	**2.3**
(ODF#15)	**1**	**0**	**0**	**0**	**0**	**3**	**4**	**2**	**1**	**72**	**6.55**	**4.2**	**2.1**
(ODF#16)	**0**	**0**	**0**	**2**	**0**	**3**	**1**	**4**	**1**	**74**	**6.73**	**2.8**	**1.7**
Composite Values											**6.95**	**3.18**	**1.74**

Table 5.7: Technological Factors and Sub-Factors List with Mean Influence

Decision Factors	1	2	3	4	5	6	7	8	9	Total	Mean Influence	Variance	Standard Deviation
Technological													
(ODF#17)	**0**	**0**	**2**	**0**	**1**	**1**	**4**	**2**	**1**	**70**	**6.36**	**3.8**	**1.9**
(ODF#18)	**0**	**1**	**1**	**2**	**1**	**1**	**2**	**3**	**0**	**62**	**5.64**	**4.6**	**2.1**
(ODF#19)	**0**	**0**	**1**	**0**	**2**	**3**	**3**	**0**	**2**	**70**	**6.36**	**3.0**	**1.7**
(ODF#20)	**1**	**0**	**1**	**1**	**4**	**0**	**3**	**0**	**1**	**58**	**5.27**	**4.8**	**2.2**
(ODF#21)	**0**	**1**	**2**	**0**	**0**	**1**	**2**	**3**	**2**	**70**	**6.36**	**6.45**	**2.54**
(ODF#22)	**0**	**0**	**1**	**0**	**2**	**1**	**1**	**3**	**3**	**77**	**7.0**	**4.0**	**2.0**
Composite Values											**6.16**	**4.44**	**2.07**

Table 5.8: Economic Factors and Sub-Factors List with Mean Influence

Decision Factors	1	2	3	4	5	6	7	8	9	Total	Mean Influence	Variance	Standard Deviation
Economic													
(ODF#23)	**0**	**0**	**1**	**0**	**0**	**0**	**4**	**3**	**3**	**82**	**7.45**	**3.0**	**1.7**
(ODF#24)	**0**	**0**	**0**	**0**	**2**	**2**	**3**	**2**	**2**	**77**	**7.0**	**2.0**	**1.4**
(ODF#25)	**1**	**0**	**2**	**0**	**1**	**2**	**2**	**2**	**1**	**63**	**5.73**	**6.2**	**2.5**
(ODF#26)	**1**	**0**	**0**	**0**	**2**	**2**	**1**	**2**	**3**	**73**	**6.64**	**7.0**	**2.6**
(ODF#27)	**3**	**2**	**5**	**0**	**0**	**1**	**0**	**0**	**0**	**28**	**2.54**	**2.0**	**1.4**
(ODF#28)	**1**	**1**	**3**	**0**	**0**	**1**	**3**	**2**	**0**	**55**	**5.0**	**6.8**	**2.6**
(ODF#29)	**0**	**0**	**1**	**1**	**4**	**2**	**2**	**1**	**0**	**61**	**5.55**	**2.0**	**1.4**
Composite Values											**5.7**	**4.14**	**1.94**

Table 5.9: Quality Factors and Sub-Factors List with Mean Influence

Decision Factors	1	2	3	4	5	6	7	8	9	Total	Mean Influence	Variance	Standard Deviation
Quality													
(ODF#30)	**0**	**0**	**0**	**1**	**2**	**0**	**2**	**3**	**3**	**79**	**7.2**	**3.16**	**1.78**
(ODF#31)	**0**	**0**	**0**	**0**	**1**	**0**	**2**	**4**	**4**	**87**	**7.91**	**1.5**	**1.2**
(ODF#32)	**0**	**0**	**0**	**0**	**1**	**1**	**4**	**1**	**4**	**83**	**7.55**	**1.87**	**1.36**
(ODF#33)	**0**	**0**	**1**	**0**	**1**	**0**	**1**	**6**	**2**	**81**	**7.36**	**3.2**	**1.8**
Composite Values											**7.5**	**2.43**	**1.54**

Table 5.10: Function Characteristics Factors and Sub-Factors List with Mean Influence

Decision Factors	1	2	3	4	5	6	7	8	9	Total	Mean Influence	Variance	Standard Deviation
Function Characteristics													
(ODF#34)	**0**	**1**	**1**	**0**	**3**	**4**	**0**	**2**	**0**	**60**	**5.45**	**3.27**	**1.8**
(ODF#35)	**0**	**0**	**0**	**1**	**0**	**0**	**7**	**2**	**1**	**78**	**7.1**	**1.5**	**1.22**
(ODF#36)	**1**	**0**	**1**	**2**	**1**	**1**	**0**	**1**	**4**	**67**	**6.1**	**7.7**	**2.88**
(ODF#37)	**2**	**0**	**1**	**0**	**0**	**1**	**4**	**2**	**1**	**64**	**5.82**	**7.96**	**2.8**
(ODF#38)	**1**	**1**	**1**	**0**	**3**	**0**	**2**	**1**	**2**	**61**	**5.55**	**5.56**	**2.36**
Composite Values											**6.0**	**5.2**	**2.21**

Table 5.11: Outsourcing Decision Factors List with Mean Influence

Decision Factors	1	2	3	4	5	6	7	8	9	Total	Mean Influence	Variance	Standard Deviation
Strategic	**0**	**1**	**0**	**0**	**1**	**0**	**3**	**4**	**2**	**78**	**7.1**	**4.1**	**2.01**
Management	**0**	**0**	**0**	**0**	**1**	**2**	**5**	**2**	**1**	**77**	**7.0**	**1.2**	**1.1**
Technological	**0**	**0**	**1**	**0**	**2**	**3**	**2**	**0**	**3**	**72**	**6.5**	**3.7**	**1.9**
Economic	**0**	**0**	**0**	**1**	**1**	**2**	**1**	**3**	**3**	**79**	**7.2**	**2.96**	**1.7**
Quality	**0**	**0**	**0**	**0**	**1**	**1**	**2**	**3**	**4**	**85**	**7.7**	**1.8**	**1.35**
Function Characteristics	**0**	**0**	**1**	**0**	**1**	**2**	**2**	**2**	**3**	**77**	**7.0**	**3.6**	**1.9**

Table 5.12: Alternatives List with Mean Influence

Category	Decision Factors	Outsource		Not-Outsource	
		Total	Mean Influence	Total	Mean Influence
Strategic	(ODF#1)	39.3	3.6	42.4	3.86
	(ODF#2)	48.7	4.43	26.7	2.43
	(ODF#3)	34.6	3.14	36	3.3
	(ODF#4)	42.4	3.86	23.6	2
	(ODF#5)	51.8	4.7	25	2.3
	(ODF#6)	50.3	4.6	11	1
	(ODF#7)	53.4	4.86	26.7	2.43
	(ODF#8)	56.6	5	12.6	1.143
	(ODF#9)	58	5.3	1	0.1
Management	(ODF#10)	53.4	4.86	28.3	2.6
	(ODF#11)	53.4	4.86	22	2
	(ODF#12)	64.4	5.9	20	1.86
	(ODF#13)	66	6	14	1.3
	(ODF#14)	56.6	5	87.8	0.71
	(ODF#15)	66	6	11	1
	(ODF#16)	42	3.86	25	2.3
	(ODF#17)	56.6	5	12.6	1.14
	(ODF#18)	48.7	4.43	17.3	1.6

Table 5.13: Alternatives List with Mean Influence

Category	Decision Factors	Outsource		Not-Outsource	
		Total	Mean Influence	Total	Mean Influence
Technological	(ODF#19)	58	5.3	1	0.1
	(ODF#20)	59.7	5.43	4.7	0.42
	(ODF#21)	67,6	6	4.7	0.42
	(ODF#22)	59.7	5.43	4.7	0.42
Economic	(ODF#23)	50.3	4.6	9.4	0.8
	(ODF#24)	64.4	5.86	8	0.72
	(ODF#25)	63	5.7	1	0.1
	(ODF#26)	44	4	20	1.86
	(ODF#27)	23.6	2	11	1
	(ODF#28)	45.6	4	3	0.3
	(ODF#29)	37.7	3.43	8	0.72
Quality	(ODF#30)	61	5.6	12.6	1.143
	(ODF#31)	69	6.3	12.6	1.143
	(ODF#32)	66	6	11	1
	(ODF#33)	69	6.3	3	0.3
Function Characteristics	(ODF#34)	38	3.43	11	1
	(ODF#35)	52	4.7	12.6	1.143
	(ODF#36)	69	6.3	0	0
	(ODF#37)	70.6	6.43	0	0
	(ODF#38)	52	4.7	4.7	0.43

5.2.2.4 Pairwise Comparison

When the hierarchy has been built, the procedure of prioritizing begins to determine the relative importance of the factors on each level. A pair-wise comparison in Expert Choice is the process of comparing the relative importance, preference or likelihood of two factors with respect to another factor in the level above. On each level of the hierarchy, the pair-wise comparisons were carried out in top-down approach. All the factors under any node were compared with each other with respect to the node itself. The Tables (5.14-5.20) show the pairwise comparisons for all categories and factors and the Tables (5.21-5.58) show the pairwise comparisons for all alternatives with respect to each factor.

Table 5.14: Main Categories Pairwise Comparison

Categories	Management	Economic	Technological	Quality	Function Ch
Strategic	**1.01**	**0.98**	**1.1**	**0.92**	**1.01**
Management	**1.0**	**0.97**	**1.07**	**0.9**	**1.0**
Economic		**1.0**	**1.1**	**0.9**	**1.03**
Technological			**1.0**	**0.84**	**0.9**
Quality				**1.0**	**1.1**
Function Ch					**1.0**

Table 5.15: Pair wise Comparison of Strategic Factors

Strategic Factors	(ODF#2)	(ODF#3)	(ODF#4)	(ODF#5)	(ODF#6)	(ODF#7)	(ODF#8)	(ODF#9)
(ODF#1)	0.95	1.1	1.18	0.92	1.1	0.94	0.96	1.24
(ODF#2)	1.0	1.17	1.24	0.96	1.14	0.99	1.01	1.3
(ODF#3)		1.0	1.06	0.83	0.97	0.85	0.86	1.1
(ODF#4)			1.0	0.78	0.92	0.8	0.81	1.05
(ODF#5)				1.0	1.18	1.02	1.05	1.35
(ODF#6)					1.0	0.86	0.89	1.14
(ODF#7)						1.0	1.02	1.3
(ODF#8)							1.0	1.3
(ODF#9)								1.0

Table 5.16: Pairwise Comparison of Management Factors

Management Factors	(ODF#11)	(ODF#12)	(ODF#13)	(ODF#14)	(ODF#15)	(ODF#16)
(ODF#10)	1.1	1.02	0.9	1.34	1.15	1.12
(ODF#11)	1.0	0.9	0.85	1.2	1.04	1.01
(ODF#12)		1.0	0.92	1.3	1.12	1.09
(ODF#13)			1.0	1.42	1.22	1.19
(ODF#14)				1.0	0.86	0.84
(ODF#15)					1.0	0.97
(ODF#16)						1.0

Table 5.17: Pairwise Comparison of Technological Factors

Technological Factors	(ODF#18)	(ODF#19)	(ODF#20)	(ODF#21)	(ODF#22)
(ODF#17)	1.13	1	1.2	1	0.9
(ODF#18)	1.0	0.88	1.07	0.88	0.80
(ODF#19)		1.0	1.2	1	0.9
(ODF#20)			1.0	0.83	0.75
(ODF#21)				1.0	0.9
(ODF#22)					1.0

Table 5.18: Pair wise Comparison of Economic Factors

Economic Factors	(ODF#24)	(ODF#25)	(ODF#26)	(ODF#27)	(ODF#28)	(ODF#29)
(ODF#23)	1.06	1.3	1.12	2.9	1.5	1.34
(ODF#24)	1.0	1.2	1.05	2.8	1.4	1.26
(ODF#25)		1.0	0.86	2.3	1.15	1.03
(ODF#26)			1.0	2.6	1.23	1.2
(ODF#27)				1.0	0.5	0.46
(ODF#28)					1.0	0.9
(ODF#29)						1.0

Table 5.19: Pairwise Comparison of Quality Factors

Quality Factors	(ODF#31)	(ODF#32)	(ODF#33)
(ODF#30)	**0.91**	**0.95**	**0.98**
(ODF#31)	**1.0**	**1.05**	**1.07**
(ODF#32)		**1.0**	**1.02**
(ODF#33)			**1.0**

Table 5.20: Pairwise Comparison of Function Characteristics Factors

Function Characteristics Factors	(ODF#35)	(ODF#36)	(ODF#37)	(ODF#38)
(ODF#34)	**0.77**	**0.89**	**0.94**	**0.98**
(ODF#35)	**1.0**	**1.16**	**1.2**	**1.28**
(ODF#36)		**1.0**	**1.05**	**1.1**
(ODF#37)			**1.0**	**1.05**
(ODF#38)				**1.0**

Table 5.21: Alternatives with Respect to Focus on Core Activities

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**0.94**
Not-Outsource	**1.06**	**1**

Table 5.22: Alternatives with Respect to Access to World-Class Capabilities

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**1.82**
Not-Outsource	**0.55**	**1**

Table 5.23: Alternatives with Respect to Freeing Resource for Core Activities

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**0.95**
Not-Outsource	**1.05**	**1**

Table 5.24: Alternatives with Respect to Accelerate Re-Engineering Benefits

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**1.93**
Not-Outsource	**0.52**	**1**

Table 5.25: Alternatives with Respect to Risk Sharing with Contractors

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**2.03**
Not-Outsource	**0.5**	**1**

Table 5.26: Alternatives with Respect Lack of Internal Resources for a Service

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**4.6**
Not-Outsource	**0.22**	**1**

Table 5.27: Alternatives with Respect Improve Flexibility to the Changing Market Dynamics

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**2**
Not-Outsource	**0.5**	**1**

Table 5.28: Alternatives with Respect to Strategic Alliance with Contractors

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**4.36**
Not-Outsource	**0.23**	**1**

Table 5.29: Alternatives with Respect to Regulation Governing Outsourcing Practices

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**5.31**
Not-Outsource	**0.19**	**1**

Table 5.30: Alternatives with Respect to Save the Management Time

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**1.87**
Not-Outsource	**0.53**	**1**

Table 5.31: Alternatives with Respect to Reduce the Management Load

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**2.43**
Not-Outsource	**0.4**	**1**

Table 5.32: Alternatives with Respect to Need for Specialized Management

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**3.17**
Not-Outsource	**0.3**	**1**

Table 5.33: Alternatives with Respect to Increase the Speed of Implementation

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**4.6**
Not-Outsource	**0.22**	**1**

Table 5.34: Alternatives with Respect to Function Difficult to Manage

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**5.01**
Not-Outsource	**0.2**	**1**

Table 5.35: Alternatives with Respect to Safety Management

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**6**
Not-Outsource	**0.167**	**1**

Table 5.36: Alternatives with Respect to Consolidation or Decentralization

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**1.68**
Not-Outsource	**0.6**	**1**

Table 5.37: Alternatives with Respect to Flexibility with Changing Technology

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**4.39**
Not-Outsource	**0.23**	**1**

Table 5.38: Alternatives with Respect to Initiate Innovative Ideas and Techniques

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**2.76**
Not-Outsource	**0.36**	**1**

Table 5.39: Alternatives with Respect to Improve the Technology for Competitive Advantage

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**5.31**
Not-Outsource	**0.19**	**1**

Table 5.40: Alternatives with Respect to Technology Requirements Uncertainty

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**4.44**
Not-Outsource	**0.22**	**1**

Table 5.41: Alternatives with Respect to Need for Specialized Expertise

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**6**
Not-Outsource	**0.167**	**1**

Table 5.42: Alternatives with Respect to Acquire New Skills or Technical Knowledge

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**5.41**
Not-Outsource	**0.18**	**1**

Table 5.43: Alternatives with Respect to Save the Overall Cost

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**4.6**
Not-Outsource	**0.2**	**1**

Table 5.44: Alternatives with Respect to Reduce the Labour and Operating Cost

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**5.87**
Not-Outsource	**0.17**	**1**

Table 5.45: Alternatives with Respect make the Fixed Costs into Variable Costs

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**5.71**
Not-Outsource	**0.17**	**1**

Table 5.46: Alternatives with Respect to Improve the Cash Flow

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**2.15**
Not-Outsource	**0.46**	**1**

Table 5.47: Alternatives with Respect to Cash Infusion

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**2**
Not-Outsource	**0.5**	**1**

Table 5.48: Alternatives with Respect to Make Capital Funds more Available for Core Activities

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**4**
Not-Outsource	**0.25**	**1**

Table 5.49: Alternatives with Respect to Increase the Economic Efficiency

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**3.43**
Not-Outsource	**0.29**	**1**

Table 5.50: Alternatives with Respect to Improve Service Quality

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**4.89**
Not-Outsource	**0.2**	**1**

Table 5.51: Alternatives with Respect to Improve Quality Requirement

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**5.49**
Not-Outsource	**0.18**	**1**

Table 5.52: Alternatives with Respect to Achieve High Quality of Service for Competitive Advantage

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**6**
Not-Outsource	**0.167**	**1**

Table 5.53: Alternatives with Respect to Procure Reliability and Competency

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**6.31**
Not-Outsource	**0.16**	**1**

Table 5.54: Alternatives with Respect to the Complexity of Function

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**3.43**
Not-Outsource	**0.3**	**1**

Table 5.55: Alternatives with Respect to Function Integration and Structure

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**4.1**
Not-Outsource	**0.24**	**1**

Table 5.56: Alternatives with Respect to Lack of Spare Parts

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**6.31**
Not-Outsource	**0.16**	**1**

Table 5.57: Alternatives with Respect to Function Difficult to Control

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**6.41**
Not-Outsource	**0.15**	**1**

Table 5.58: Alternatives with Respect to Lack in Equipment/Tools Availability

Alternatives	Outsource	Not-Outsource
Outsource	**1**	**4.71**
Not-Outsource	**0.2**	**1**

5.2.2.5 Calculating Priorities

The relative weights of the factors were calculated after the completion of the pair-wise comparisons. The calculation of relative priorities for each decision factor through a number of numerical calculations was made. Finally, these results were synthesized into an overall priority list. The steps of calculating priorities are:

- Let n set of factors that needed to compare. For example, the main categories were arranged in the n×n AHP matrix and compared.
- After the matrix was made, sum the values in each column of the pairwise comparison matrix.
- To normalize the sum of rows convert each value to the percentage of its column total. Divide each element in the pairwise comparison matrix by its column sum and normalized pairwise comparison matrix was resulted.
- Compute the average of the elements in each row of the normalized matrix. These averages provide relative importance of each category. Table 5.59 shows the relative importance of each category.

Table 5.59: Relative Importance of each category

Categories	Management	Economic	Technological	Quality	Function Characteristic	Priority
Strategic	**0.166**	**0.16**	**0.167**	**0.17**	**0.167**	**0.166**
Management	**0.164**	**0.16**	**0.16**	**0.16**	**0.166**	**0.162**
Economic	**0.17**	**0.17**	**0.167**	**0.16**	**0.17**	**0.167**
Technological	**0.15**	**0.15**	**0.15**	**0.15**	**0.15**	**0.15**
Quality	**0.18**	**0.19**	**0.18**	**0.18**	**0.18**	**0.18**
Function Characteristic	**0.166**	**0.16**	**0.167**	**0.16**	**0.166**	**0.164**

5.2.2.6 Estimation of Consistency

After the relative priority was calculated, decision maker is allowed by Expert Choice Software to change preferences and to test the results if the inconsistency level is considered high. For calculation of consistency, the steps are:

- When the sum of the rows is averaged as the previous example, this yields row vector of priorities (0.166, 0.162, 0.167, 0.15, 0.18, and 0.164).
- Multiply each value in the first column of the pairwise comparison matrix by corresponding relative priority matrix, a new column vector will be obtained as shown in Table 5.60.

Table 5.60: New Column Vector Obtained

Category	Strategic	Management	Economic	Technological	Quality	Function Char	Sum of Rows
Strategic	**0.17**	**0.16**	**0.187**	**0.138**	**0.18**	**0.16**	**0.995**
Management	**0.17**	**0.157**	**0.187**	**0.135**	**0.18**	**0.16**	**0.989**
Economic	**0.187**	**0.162**	**0.187**	**0.135**	**0.185**	**0.165**	**1.021**
Technological	**0.15**	**0.146**	**0.17**	**0.126**	**0.162**	**0.15**	**0.904**
Quality	**0.187**	**0.18**	**0.204**	**0.15**	**0.2**	**0.18**	**1.101**
Function Ch	**0.17**	**0.157**	**0.187**	**0.135**	**0.18**	**0.16**	**0.989**

- Divide the first element of the column vector by the first component of the row vector, the second element of the column vector by the second component of the row vector, we get another vector.

0.995/0.166=5.99

0.989/0.162=6.1

1.021/0.167=6.1

0.904/0.15=6.0

1.101/0.18=6.12

0.989/0.164=6.03

- The largest eigen-vector is equal to 6.12, now the sum of the components is calculated and divided by the number of components:

$$\lambda = (5.99+6.1+6.1+6.0+6.12+6.03)/6 = 36.34/6 = 6.056$$

- The consistency index is defined as $(\lambda - n) / (n-1)$.

$$CI = (6.056- 6) / (6-1) = 0.01/5 = 0.01$$

- Random Index was taken from the following Table (Satty, 1990a):

Table 5.61: Random Index (RI) (Satty, 1990a)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
0	0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

RI = 1.24

- The consistency ratio is calculated by dividing consistency index with random index

CR = 0.01/1.24 = 0.009 the CR is less than **0.1**

5.3 Discussion of Results

5.3.1 Strategic Category

The overall ranking of strategic factors is shown in Figure 5.2. It shows the priority obtained by adding up the values of overall importance. The results are presented in bar graph form, and present the different factors from most important to least important. As shown, the priority is to risk sharing with contractor factor that had a weight of 0.125, then improve flexibility to the changing market dynamics factor that had a weight of 0.122, followed by access to world-class capabilities factor that had a weight of 0.120, and with least priority given to regulations governing the outsourcing practices factor that had a weight of 0.093. With this analysis, risk sharing with contractor and improve flexibility to the changing market dynamics factor are considered relatively important with regard to the strategic category. The top three strategic factors are as follows:

- **Risk sharing with contractors:** It is ranked as the most important factor for the strategic category. It appear that working in risky environment enables the maintenance departments of universities prefer to reduce them by finding a contractor with advanced expertise. This indicates that contractors have experience and all means to deal with the risks more than in-house.

- **Improve flexibility to the changing market dynamics:** It is ranked as the second important factor. This indicates that outsourcing increases flexibility through the

better use of internal resources enables quick responsiveness to customer needs and improved responsiveness to changing market demand.

- **Access to world-class capabilities:** It is ranked as the third important factor. It appears that outsourcing may enable the maintenance departments of universities to make up the quality of maintenance services. Alliance with specialized contractors can offer access to new technology, tools and techniques that universities may not currently possess.

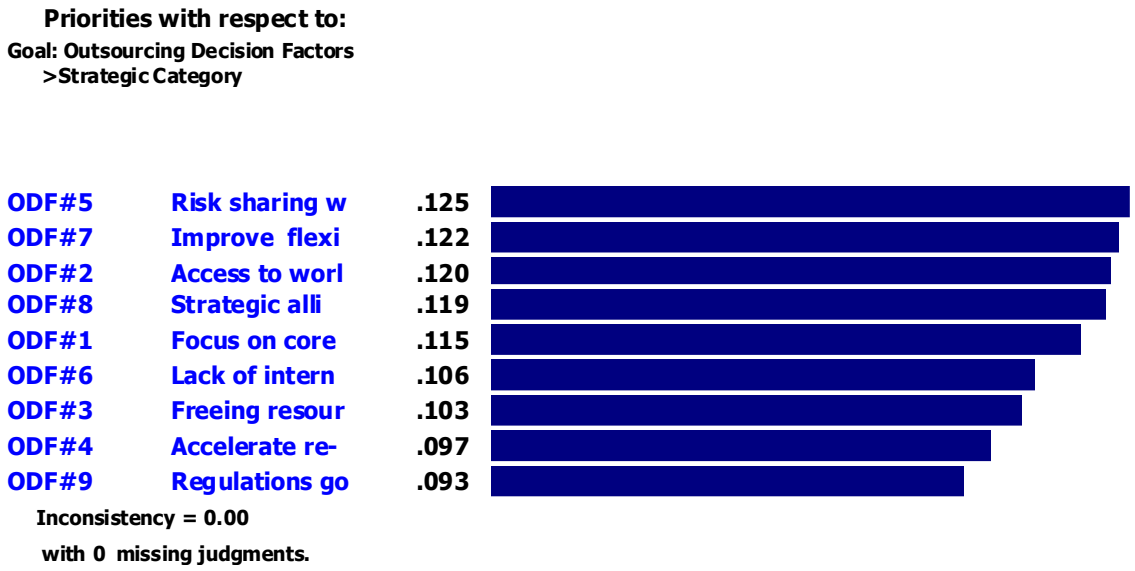


Figure 5.2: Overall Ranking with Respect to Strategic Category

5.3.2 Management Category

An effective management is a means for achieving a high standard of maintenance work. In absence of effective management, it leads to time consuming, and probably failing maintenance work (Mahmoud, 1994). The overall ranking of management factors is as shown in Figure 5.3. As shown, increase the speed of implementation factor had a weight of 0.165, save the management time factor had a weight of 0.154, and need for specialized management factor had a weight of 0.152, and with least priority given to function difficult to manage factor that had a weight of 0.116. With this analysis, increase the speed of implementation factor and save the management time factor is considered relatively important with regard to the management category. The top three management factors are as follows:

- **Increase the speed of implementation:** It is ranked as the most important factor for the management category. This indicates that a contractor is well versed in the technical and administrative requirements and qualified staff necessary to put applications to perform services in the effective way.

- **Save the management time:** It is ranked as the second important factor. It appears that outsourcing allow the maintenance department management to concentrate on core-activities to perform them in perfect way. The contractors must be well qualified with capability in organizing and directing works in the minimum time with high quality.

- **Need for specialized management:** It is ranked as the third important factor. This reflects the contractors have all levels of maintenance work force available wherever they are needed. Maintenance services require technical expertise that is not present within universities or they can not hire employees with required expertise.

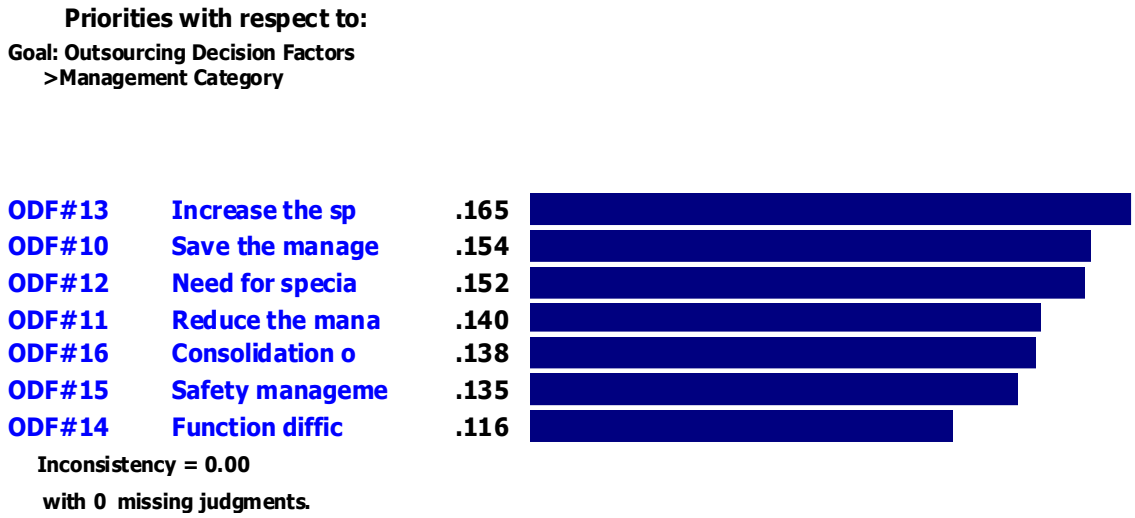


Figure 5.3: Overall Ranking with Respect to Management Category

5.3.3 Technological Category

The overall ranking of the technological factors for the decision to outsource the maintenance services is as shown in Figure 5.4. As shown, acquire new skills or technical knowledge factor had a weight of 0.189, achieve flexibility with changing technology factor had a weight of 0.172, and improve the technology for competitive advantage factor had a weight of 0.172. Acquire new skills or technical knowledge factor, and achieve flexibility with changing technology factor are considered relatively important with regards to the technological category. The top three technological factors are as follows:

- **Acquire new skills or technical knowledge:** It is ranked as the most important factor for the technological category. This indicates the Saudi universities adopt outsourcing to gain access to new technology and outside expertise that the contractors have.

- **Achieve flexibility with changing technology:** It is ranked as the second important factor. It appears that the universities concern to achieve flexibility with rapidly changing technology, so the contractors may be able to provide a high level service with a commitment to technological innovation.

- **Improve the technology for competitive advantage:** It is ranked as the third important factor. This indicates universities use outsourcing to access the technology that are unavailable, and too expensive. Successful outsourcing helps to achieve

various objectives resulting in cost saving or efficiency improvement which ultimately leads to a competitive advantage.

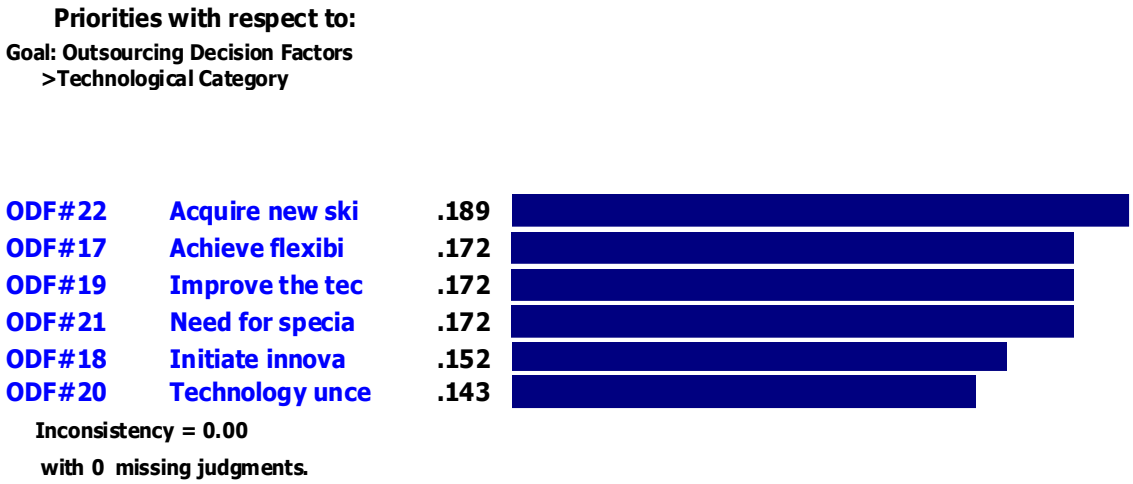


Figure 5.4: Overall Ranking with Respect to Technological Category

5.3.4 Economic Category

The overall ranking of the economic factors is shown in Figure 5.5. As shown, save the overall cost had a weight of 0.178, reduce the labour and operating cost factor had a weight of 0.176, and improve the cash flow factor had a weight of 0.166. Save the overall cost factor and reduce the labour and operating cost factor are considered relatively important with regards to the economic category. The top three economic factors are as follows:

- **Save the overall cost:** It is ranked as the most important factor for the economic category. This indicates that maintenance departments of universities adopt outsourcing as a way to reduce cost through better cost control over the outsourced function. Universities deals with contractors that specializes in a given function and performs that function more efficiently of cost saving than universities could.

- **Reduce the labour and operating cost:** It is ranked as the second important factor. The labour stands out as one of the more prominent features of the maintenance. A high percentage of non-Saudi workforces are still visible in the skilled labour areas. The gradual replacement of Saudis is taking place only at the administration level (Al-Sultan, 1996).

- **Improve the cash flow:** It is ranked as the third important factor. It can be occurred when outsourcing' costs are low enough. This indicates Saudi universities adopt outsourcing of maintenance services to improve the cash flow.

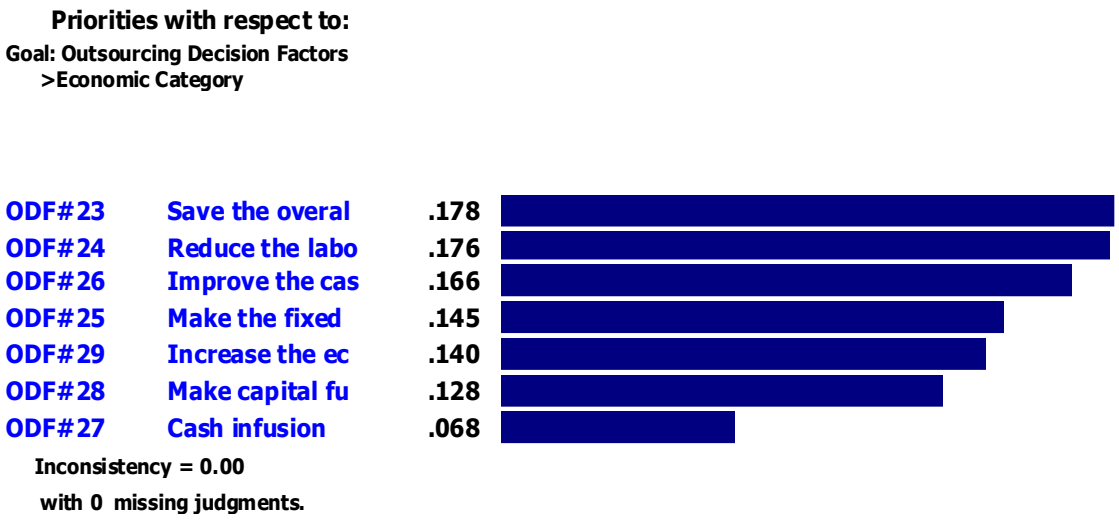


Figure 5.5: Overall Ranking with Respect to Economic Category

5.3.5 Quality Category

It is ranked as the most important category impacted on the outsourcing decision of maintenance services. The overall ranking of quality factors is as shown in Figure 5.6. As shown, improve quality requirements factor had a weight of 0.263, achieve high quality of service for competitive advantage factor had a weight of 0.251, and procure higher reliability and competency factor had a weight of 0.246. The top three quality factors are as follows:

- **Improve quality requirements:** It is ranked as the most important factor for the quality category. The importance of quality requirements is usage of technology, resources' depth of knowledge ensures that the qualities of service measures up to the highest standards and provide a range of acceptable performance values.

- **Achieve high quality of service for competitive advantage:** It is ranked as the second important factor. For services eligible for outsourcing, the key strategic is whether university can perform those services on a level that is comparable with the best in the world.

- **Procure higher reliability and competency:** It is ranked as the third important factor. To ensure high reliability and excellent performance of maintenance services and good service quality, university must set up the performance goals and service levels.

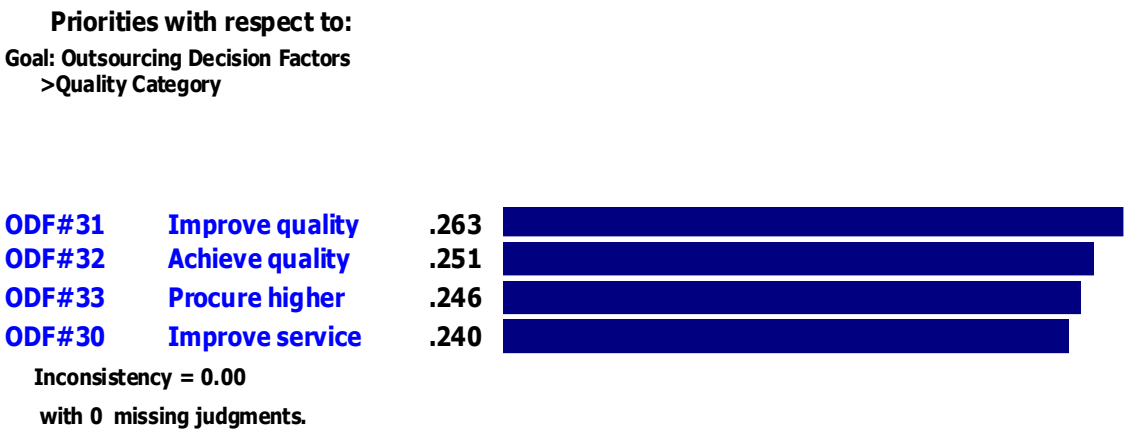


Figure 5.6: Overall Ranking with Respect to Quality Category

5.3.6 Function Characteristic Category

The overall ranking of the function characteristic factors is shown in Figure 5.7. As shown, the function integration and structure factor that had a weight of 0.236 was followed by lack of spare parts factor that had a weight of 0.204, and function difficult to control factor that had a weight of 0.194. The top three function characteristic factors are as follows:

- **Function integration and structure:** It is ranked as the most important factor for the function characteristic category. It indicates that the maintenance works considered integrated function so that more than one service may takes place in the same time. This makes the administration and coordination difficult to control.

- **Lack of spare parts:** It is ranked as the second important factor. This reflects the local market may strain to provide the many parts needed. If required spare parts were available in the local market, thus it would be cheaper and easer to perform maintenance work.

- **Function difficult to control:** It is ranked as the third important factor. This reflects that the maintenance services are difficult task due to access to the site might not be easy, space is restricted, and there is interference between building occupants and workers.

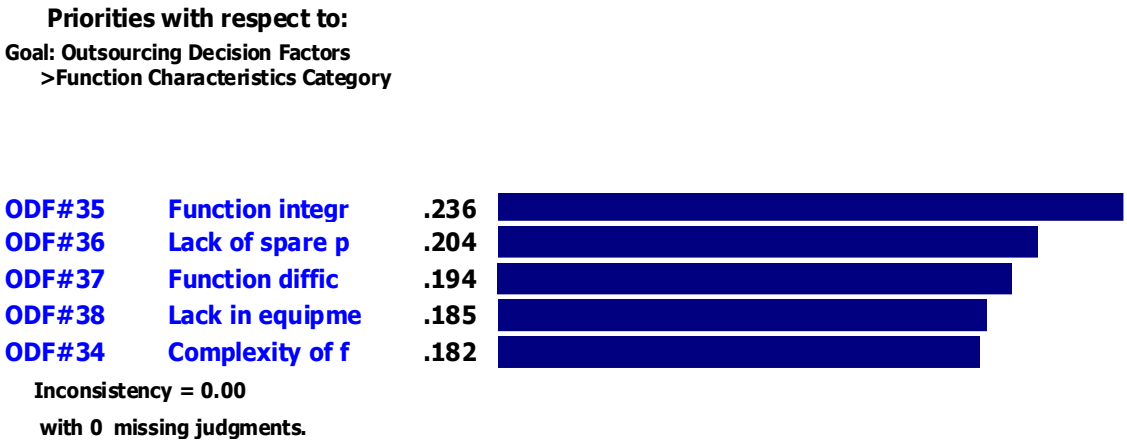


Figure 5.7: Overall Ranking with Respect to Function Characteristics Category

5.3.7 Main Categories

Figure 5.8 shows the priority index obtained by adding up the values of multiplying the overall importance for each group by the group relative importance. As a result, the Quality obtained priority of 18.5%, the Economic obtained priority of 17.1%, the Strategic obtained priority of 16.8%, the Management obtained priority of 16.6%, the Function Characteristics obtained priority of 15.8%, and the Technological obtained priority of 15.2%. The findings indicate that Quality, Economic, Strategic were the main drivers that motivate Saudi universities to outsource the maintenance services. The maintenance departments had preferred quality to others factors. Performance evaluation of planning and scheduling of maintenance work involves many measures including: meeting schedules and deadlines set by efficiency of the work schedule, and quality of the completed task.

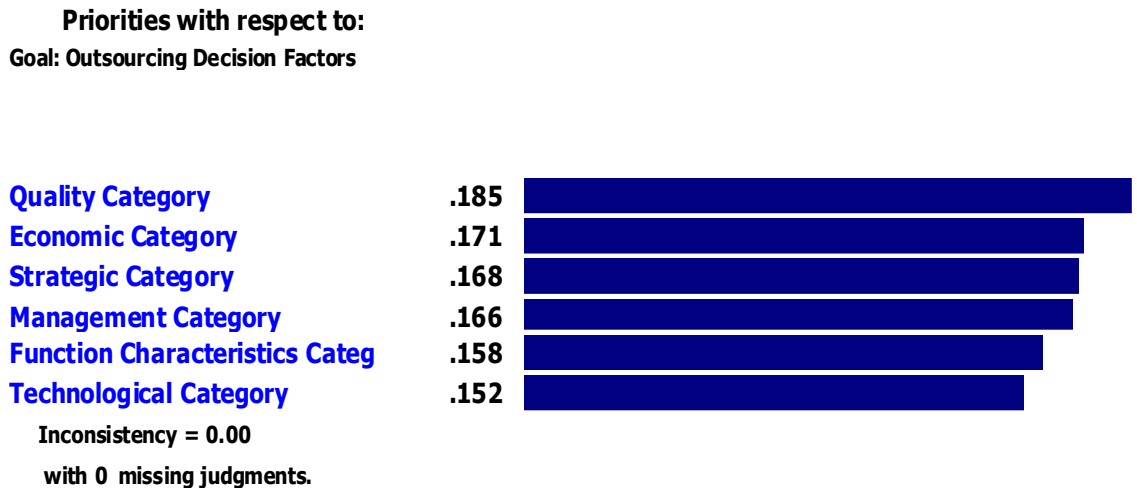


Figure 5.8: Overall Ranking with Respect to Outsourcing Decision Factors

5.3.8 Overall Factors

Table 5.62 shows the global priority of the overall factors obtained by adding up the values of overall importance. As shown, the five top factors are: improve quality requirements had a weight of 0.049, achieve high quality of service for competitive advantage had a weight of 0.047, procure higher reliability and competency had a weight of 0.046, improve service quality had a weight of 0.044, and function integration and structure had a weight of 0.037.

Table 5.62: Ranking of the Overall Factors

Category	No.	Factor	weight	Rank
Strategic	**(ODF#1)**	Focus on core activities	**0.019**	**19**
	(ODF#2)	Access to world-class capabilities	**0.020**	**18**
	(ODF#3)	Freeing resources for core activities	**0.017**	**21**
	(ODF#4)	Accelerate re-engineering benefits	**0.016**	**22**
	(ODF#5)	Risk sharing with contractors	**0.021**	**17**
	(ODF#6)	Lack of internal resources for a service	**0.018**	**20**
	(ODF#7)	Improve flexibility to the changing market dynamics	**0.020**	**18**
	(ODF#8)	Strategic alliance with contractors	**0.020**	**18**
	(ODF#9)	Regulations governing the outsourcing practices	**0.016**	**22**
Management	**(ODF#10)**	Save the management time	**0.026**	**12**
	(ODF#11)	Reduce the management load	**0.023**	**15**
	(ODF#12)	Need for specialized management	**0.025**	**13**
	(ODF#13)	Increase the speed of implementation	**0.027**	**11**
	(ODF#14)	Function difficult to manage	**0.019**	**19**
	(ODF#15)	Safety management	**0.022**	**16**
	(ODF#16)	Consolidation & decentralization	**0.023**	**15**
Technological	**(ODF#17)**	Achieve flexibility with changing technology	**0.026**	**12**
	(ODF#18)	Initiate innovative ideas & techniques	**0.023**	**15**
	(ODF#19)	Improve technology for competitive advantage	**0.026**	**12**
	(ODF#20)	Technology requirements uncertainty	**0.022**	**16**
	(ODF#21)	Need for specialized expertise	**0.026**	**12**
	(ODF#22)	Acquire new skills or technical knowledge	**0.029**	**9**
Economic	**(ODF#23)**	Save the overall cost	**0.030**	**8**
	(ODF#24)	Reduce the labour and operating cost	**0.030**	**8**
	(ODF#25)	Make the fixed costs into variable costs	**0.025**	**13**
	(ODF#26)	Improve the cash flow	**0.028**	**10**
	(ODF#27)	Cash infusion	**0.012**	**23**
	(ODF#28)	Make capital funds more available for core activities	**0.022**	**16**
	(ODF#29)	Increase the economic efficiency	**0.024**	**14**
Quality	**(ODF#30)**	Improve service quality	**0.044**	**4**
	(ODF#31)	Improve quality requirements	**0.049**	**1**
	(ODF#32)	Achieve high quality of service for competitive advantage	**0.047**	**2**
	(ODF#33)	Higher reliability and competency	**0.046**	**3**
Function Characteristics	**(ODF#34)**	Complexity of function	**0.029**	**9**
	(ODF#35)	Function integration and structure	**0.037**	**5**
	(ODF#36)	Lack of spare parts	**0.032**	**6**
	(ODF#37)	Function difficult to control	**0.031**	**7**
	(ODF#38)	Lack in equipment/tools availability	**0.029**	**9**

CHAPTER SIX

FRAMEWORK FOR DECISION ON OUTSOURCING MAINTENANCE SERVICES

6.1. Introduction

This chapter shows an application of AHP to construct a framework for the outsourcing decision-making of maintenance services on whether to outsource or not the required maintenance services. The framework is formulated in a hierarchical structure and presented as process steps defining the tasks that need to be undertaken. It can be applied by any university or private and public organization. The framework consists of sequential steps as shown in Figure 6.1.

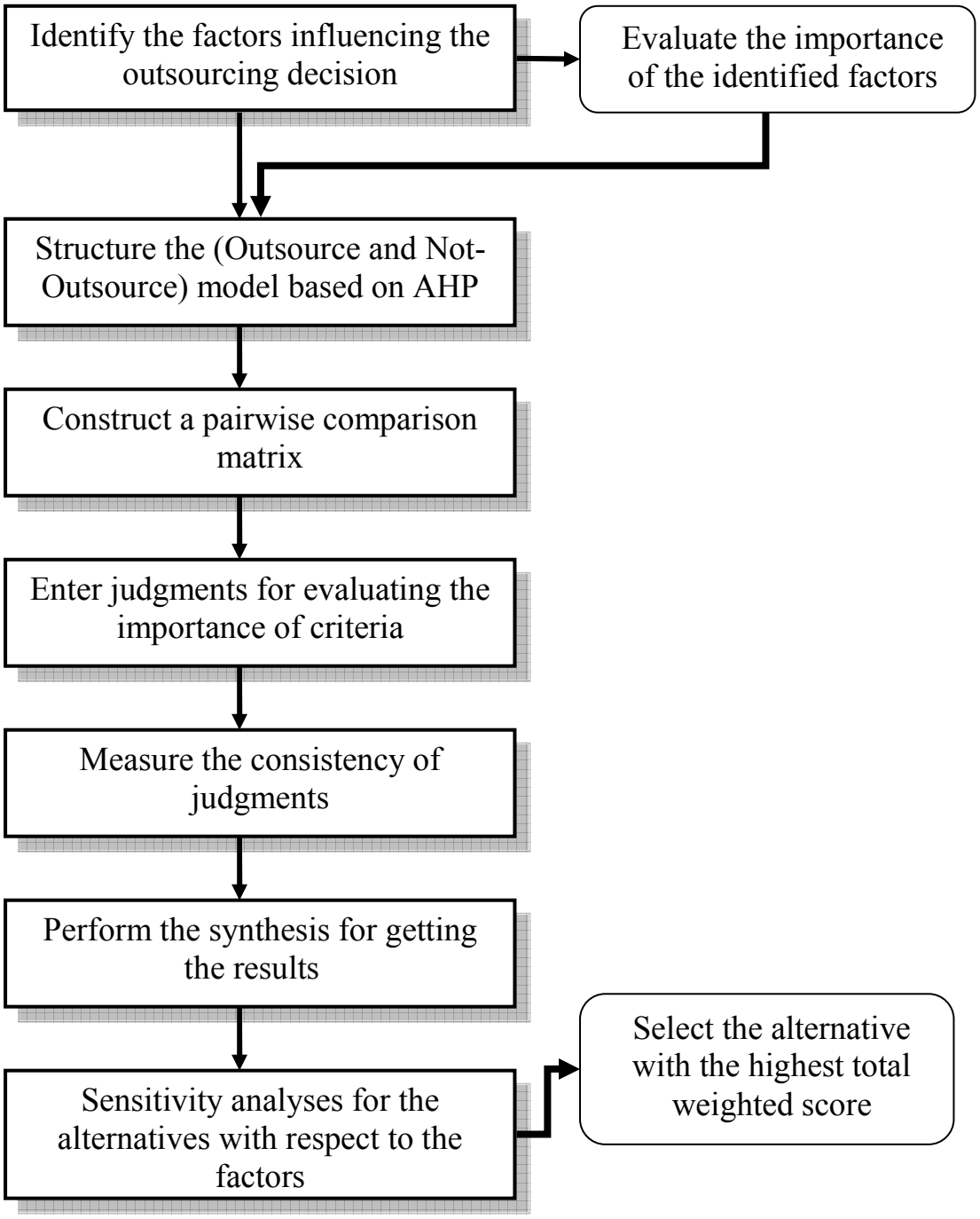


Figure 6.1: Steps Involved in the Development of the Framework

6.2 Framework of Outsourcing Decision

The framework involves carrying out nine sequential steps. Theses steps are defined and described as follows:

6.2.1 Identify the Factors Influencing the Outsourcing Decision

This function serves to identify all factors influencing the decision. The development of decision-making is based on the previously obtained factors identified and classified under six categories: Strategic; Management; Technological; Economic; Quality and Function Characteristics.

6.2.2 Evaluate the Importance of the Identified Factors

In this step, a questionnaire survey is developed and distributed to obtain a rating for each of the identified factors. The most important category of factors and the most important set of factors that have a significant bearing on the outsourcing process are identified.

6.2.3 Structure the (Outsource and Not-Outsource) Model

This function involves structuring the hierarchy designed starting from the top level and moving down into the last level of the hierarchy containing decision alternatives. At the top of the hierarchy is the most general objective of the problem, and the last level of the hierarchy contains decision choices as shown in Figure 6.2.

Figure 6.2: Hierarchy Model Developed in Expert Choice

6.2.4 Construct a Pairwise Comparison Matrix

This function serves to evaluate the identified factors by using pairwise comparisons. In order to focus judgment, the elements are put in pairs and we compare them without consideration for other factors. Figure 6.3 shows the pairwise comparison built in Expert Choice.

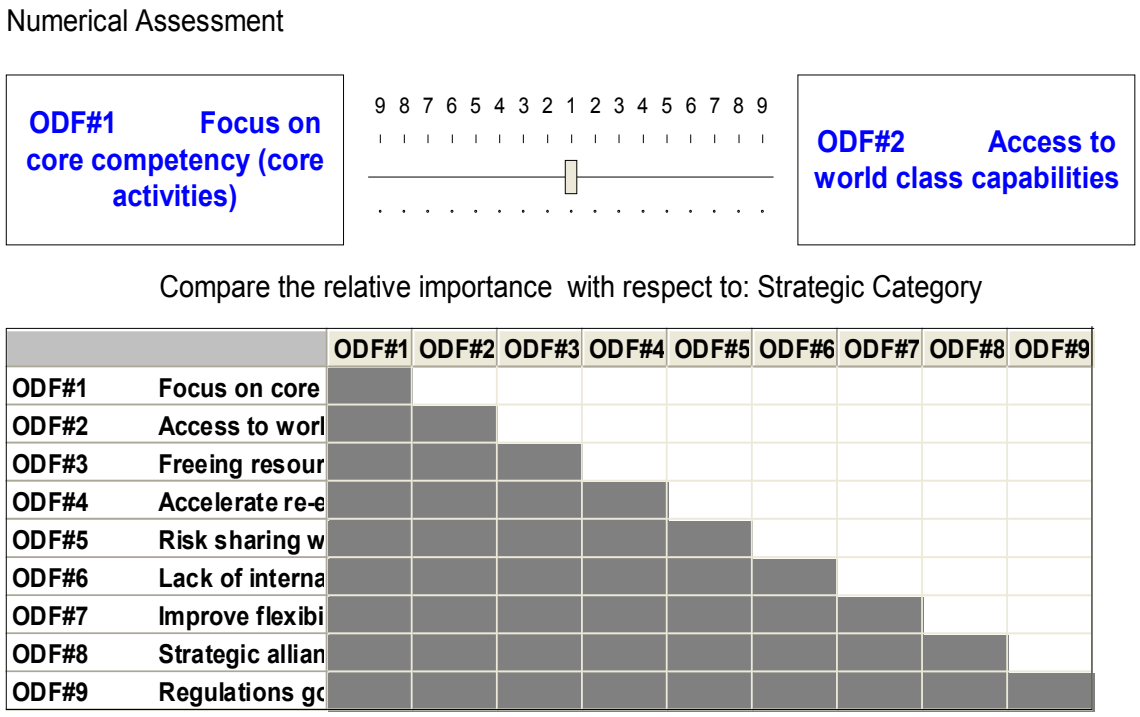
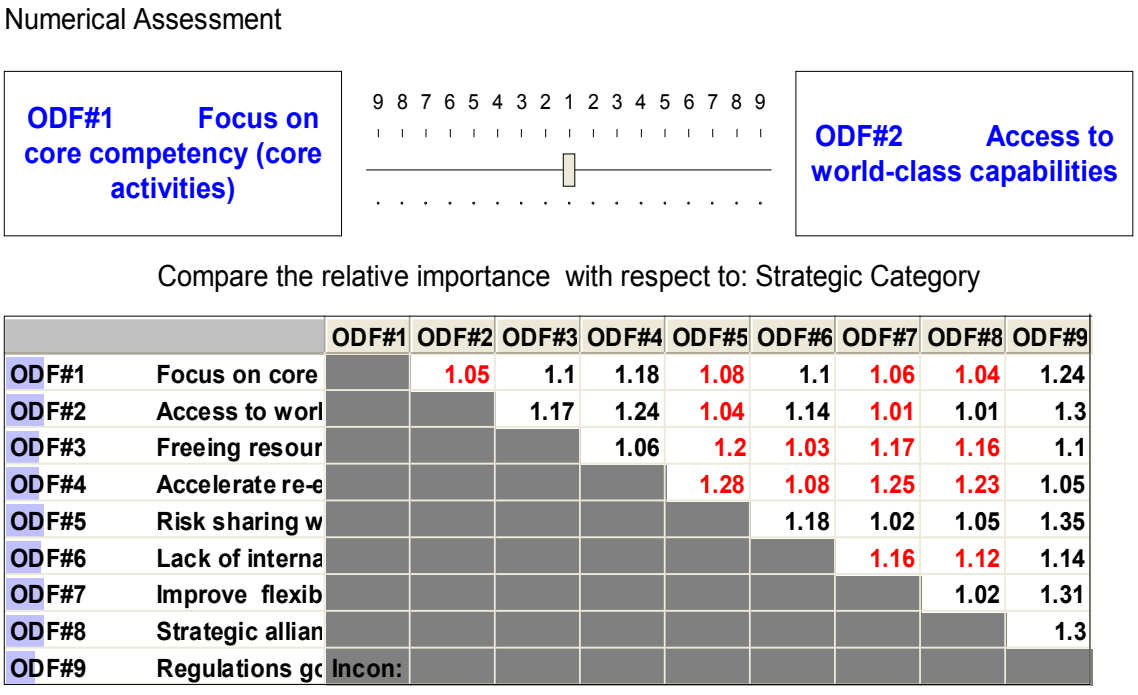


Figure 6.3: Pairwise Comparison Built in Expert Choice

6.2.5 Enter/Record Judgments for Evaluating the Factors/Alternatives

In this step, the judgments are recorded throughout pairwise comparisons built for each level as shown in Figure 6.4. The preferences of decision alternatives are entered with respect to each factor and then each factor in the above level is judged with respect to an above category. In Expert Choice, the pairwise comparisons are made by three means namely: Verbal Judgments, Numerical Judgments, and Graphical Judgments.



		ODF#1	ODF#2	ODF#3	ODF#4	ODF#5	ODF#6	ODF#7	ODF#8	ODF#9
ODF#1	Focus on core		1.05	1.1	1.18	1.08	1.1	1.06	1.04	1.24
ODF#2	Access to worl			1.17	1.24	1.04	1.14	1.01	1.01	1.3
ODF#3	Freeing resour				1.06	1.2	1.03	1.17	1.16	1.1
ODF#4	Accelerate re-e					1.28	1.08	1.25	1.23	1.05
ODF#5	Risk sharing w						1.18	1.02	1.05	1.35
ODF#6	Lack of interna							1.16	1.12	1.14
ODF#7	Improve flexib								1.02	1.31
ODF#8	Strategic allian									1.3
ODF#9	Regulations gc	Incon:								

Figure 6.4: Numerical Judgments in Pairwise Comparison Matrix

6.2.6 Measure the Consistency of Judgments

This function measures the consistency of the decision by means of consistency ratio calculated for each set of judgments. If the inconsistency ratio is zero, the judgments are considered as a complete consistency; but when the ratio is more than zero there is some inconsistency.

6.2.7 Perform the Synthesis to Obtain Results

This function serves weighting and combining priorities throughout the hierarchy leading to the overall result. Once judgments have been entered for each part of the model, the information is synthesized to achieve an overall preference. The synthesis produces a report, which ranks the alternatives in relation to the overall goal. This report includes a detailed ranking showing how each alternative was evaluated with respect to each factor.

6.2.7.1 Alternatives with Respect to Strategic Category

Figure 6.5 shows the priority index obtained by adding up the values of overall importance of alternatives with respect to strategic category. As shown, outsource alternative had a weight of 0.652, and not-outsource had a weight of 0.348.

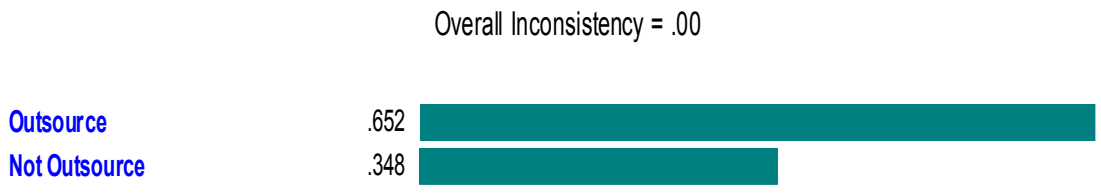


Figure 6.5: Overall Priorities of Alternatives with Respect to Strategic Category

6.2.7.2 Alternatives with Respect to Management Category

Figure 6.6 shows the priority obtained by adding up the values of overall importance of alternatives with respect to the management category. As shown, outsource alternative had a weight of 0.738, and not-outsource had a weight of 0.262. This reflects the contractors have all levels of maintenance work force available wherever they are needed for managing the services.

Figure 6.6: Overall Priorities of Alternatives with Respect to Management Category

6.2.7.3 Alternatives with Respect to Technological Category

Figure 6.7 shows the priority of importance of alternatives with respect to the technological category. As shown, outsource alternative had a weight of 0.818, and not-outsource had a weight of 0.182.

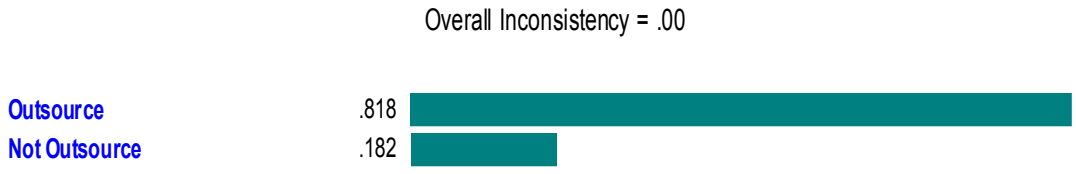


Figure 6.7: Overall Priorities of Alternatives with Respect to Technological Category

6.2.7.4 Alternatives with Respect to Economic Category

Figure 6.8 shows the priority obtained by adding up the values of overall importance of alternatives with respect to the economic category. As shown, outsource had a weight of 0.785, and not-outsource had a weight of 0.215.

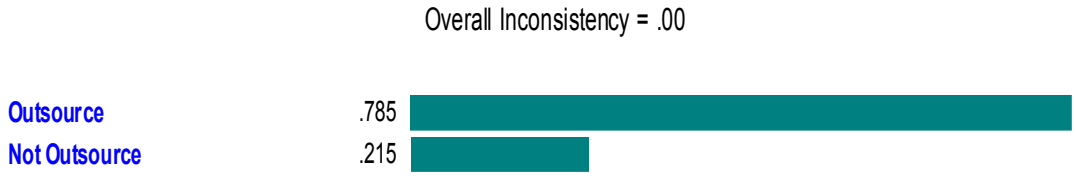


Figure 6.8: Overall Priorities of Alternatives with Respect to Economic Category

6.2.7.5 Alternatives with Respect to Quality Category

Figure 6.9 shows the priority of overall importance of alternatives with respect to the quality category. As shown, outsource had a weight of 0.849, and not-outsource had a weight of 0.151.

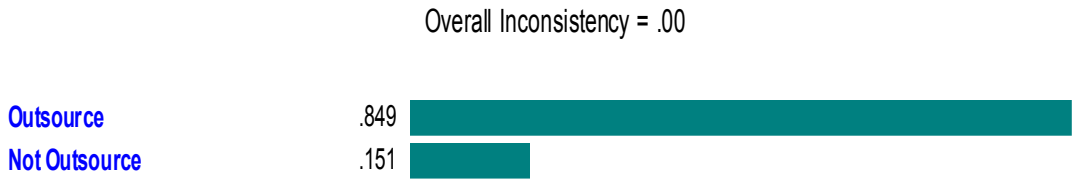


Figure 6.9: Overall Priorities of Alternatives with Respect to Quality Category

6.2.7.6 Alternatives with Respect to Function Characteristic Category

Figure 6.10 shows the priority of overall importance of alternatives with respect to the function characteristics category. As shown, outsource option had a weight of 0.825, and not-outsource had a weight of 0.175.

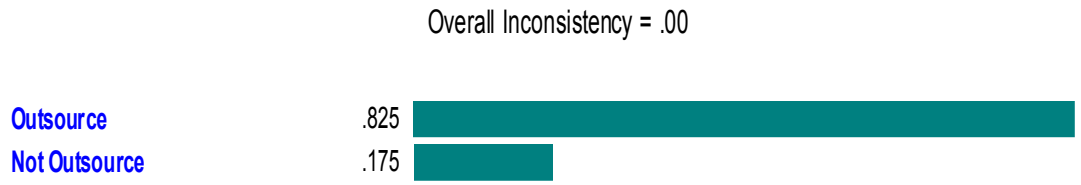


Figure 6.10: Overall Priorities of Alternatives with Respect to Function Characteristics Category

6.2.7.7 Synthesis for Alternatives with Respect to the Main Goal

Figure 6.11 shows the priority obtained by adding up the values of overall importance of alternatives. As shown, outsource had a weight of 0.772, and not-outsource had a weight of 0.228. As a result, outsource alternative obtained priority of 77% and not-outsource alternative with a priority of 23%, with an overall consistency index of 0.00.

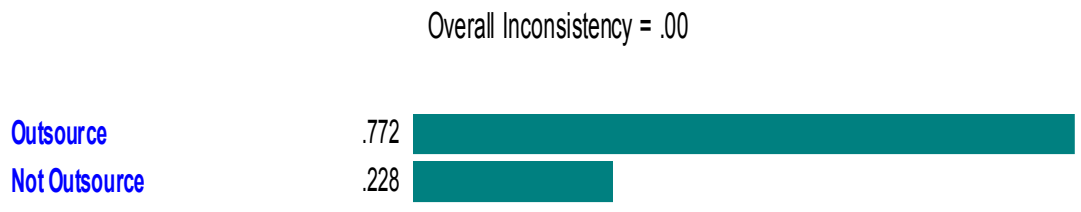


Figure 6.11: Overall Priorities of Alternatives with Respect to the Main Goal

6.2.8 Perform Sensitivity Analyses for the Alternatives

Sensitivity analyses can be performed from top of hierarchy or from the nodes to show the sensitivity of the alternatives. When performing a sensitivity analysis you can vary the priorities of the objectives and observe how the priorities of the alternatives would change. There are five types of sensitivity analysis: Dynamic, Performance, Gradient, Head to Head, and Two-Dimensional.

6.2.9 Select the Alternative with the Highest Total Weighted

Once the weights of factors and alternatives are obtained throughout the model, the select of the best alternative depends on the highest weight. Outsource alternative obtained priority of 77% so that it is the selected alternative.

6.3 Case-Study

In this section, a case-study is presented to show the application of the outsourcing decision-making framework to fulfill the fourth objective of the research. From the questionnaires distributed, it was found that most of them support the decision to outsource their maintenance services, only King Fahd University of Petroleum and Minerals did not support this decision. The university makes a contract with a supplier for supplying manpower to help its staff and holding the management and control over the service by its maintenance department. It also was found that the ratio of technicians between the university and a contractor for different maintenance services is 48.3% for the university and 51.7% for a contractor; and the procurement and purchasing of spare parts is 100% for the university and 0.0% for a contractor as shown in Table 6.1.

Table 6.1: Technicians and Materials Ratio of the University and a Contractor

Typical Maintenance Activities	Technicians %		Materials and Spare Parts %	
	Contractor	University	Contractor	University
HVAC Systems	**65%**	**35%**	**0.0%**	**100%**
Fire Protection Systems	**46%**	**54%**	**0.0%**	**100%**
Elevator Systems	**56%**	**44%**	**0.0%**	**100%**
Plumbing and Sanitary Systems	**50%**	**50%**	**0.0%**	**100%**
Electrical Systems	**30%**	**70%**	**0.0%**	**100%**
Painting	**65%**	**35%**	**0.0%**	**100%**
Construction & Renovation	**65%**	**35%**	**0.0%**	**100%**
Minor Construction	**20%**	**80%**	**0.0%**	**100%**
Carpentry	**40%**	**60%**	**0.0%**	**100%**
Steel Work	**50%**	**50%**	**0.0%**	**100%**
Telecommunication Systems	**25%**	**75%**	**0.0%**	**100%**
Electrical Appliances	**80%**	**20%**	**0.0%**	**100%**
Housekeeping &Waste Disposal	**80%**	**20%**	**0.0%**	**100%**
Average	**51.7%**	**48.3%**	**0.0%**	**100%**

The university has an experienced and qualified staff to manage and control the services so that it encourages its department to perform the services. The case study is selected to apply the model on the decision to outsource or not for HVAC system at King Fahd University of Petroleum and Minerals.

The previously identified factors, the computerized decision system (Expert Choice), and the AHP method were used to build the HVAC model. Figure 6.12 shows the model tree of (HVAC) outsourcing decision displayed from Expert Choice software. The respondent was asked to enter the judgment in the pairwise comparison matrices and

then the calculation of priorities was done and testing consistencies of the judgments for the alternatives was made.

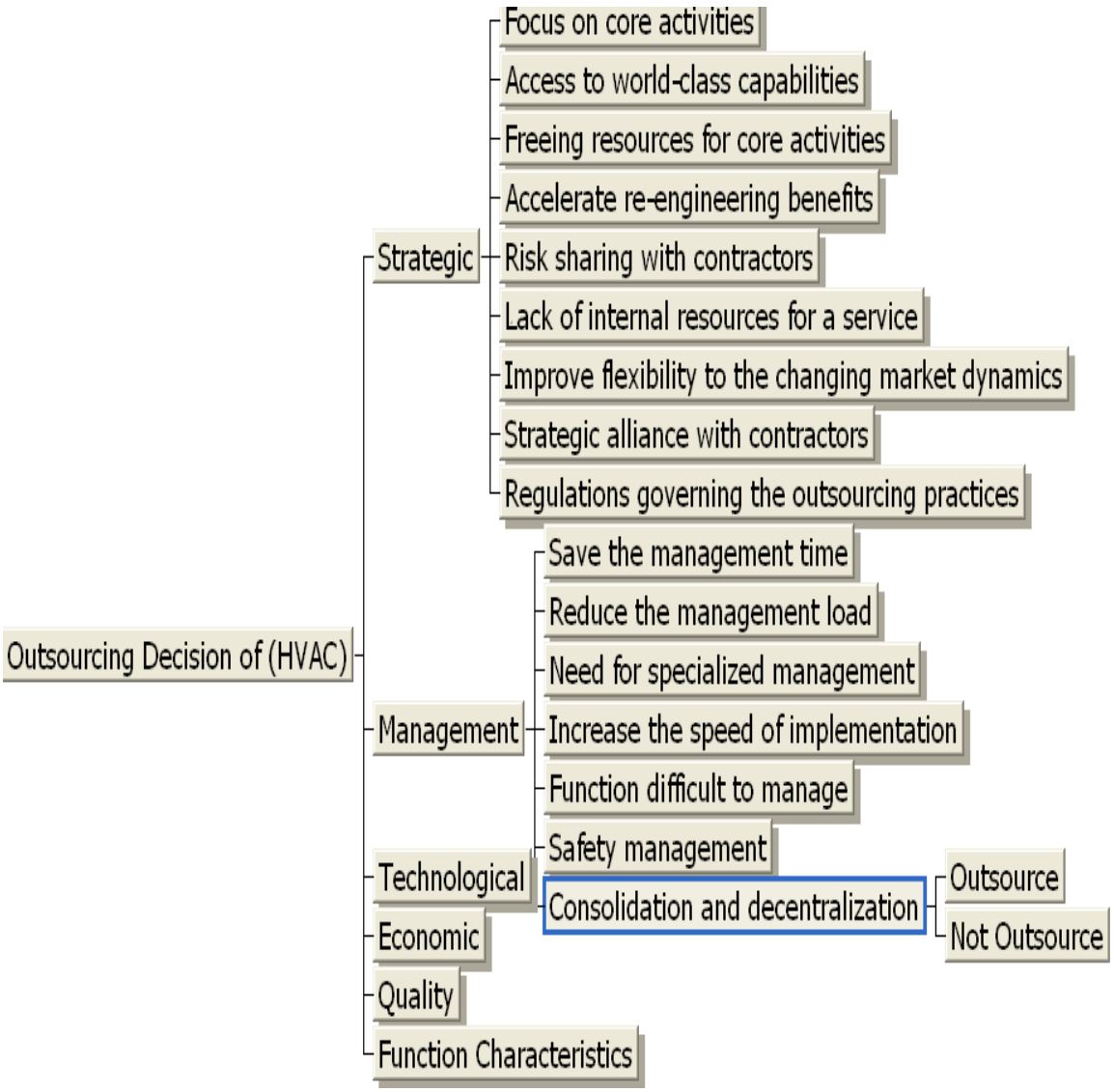


Figure 6.12: (HVAC) Hierarchy Model Displayed from Expert Choice

After entering the judgments and performing the synthesis with respect to the main goal, the software automatically displays the results in bar graph form. The weights of the six main categories are represented in Figure 6.13. As shown, the highest priority is to both technology and quality that had a weight of 0.204, and followed by management, economic, and function characteristics had a weight of 0.182 with the lowest priority to strategic category that had a weight of 0.045. Figure 6.14 shows the priority obtained by adding up the values of overall importance of alternatives. As shown, the priority is to not-outsource that had a weight of 0.605 and outsource alternative had a weight of 0.395.

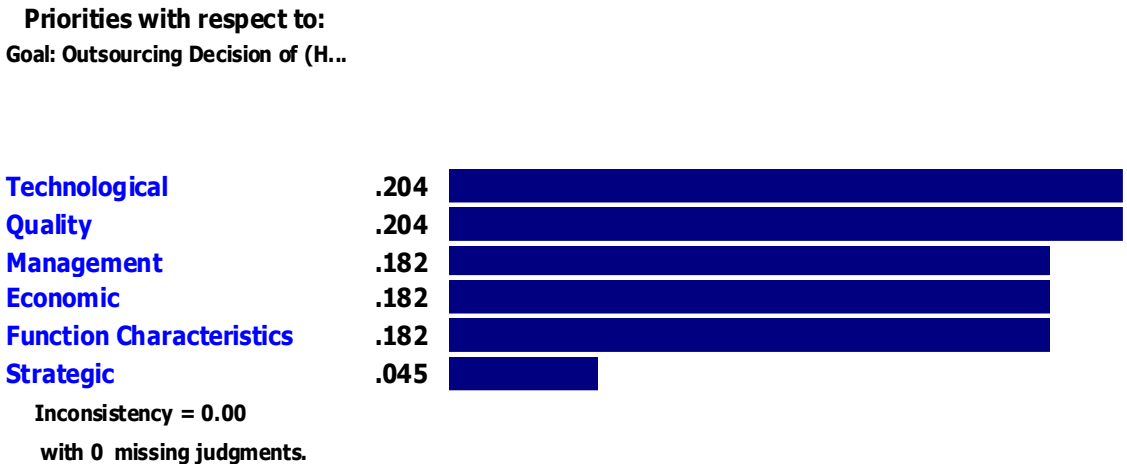


Figure 6.13: Priorities of Categories with Respect to (HVAC) Outsourcing Decision

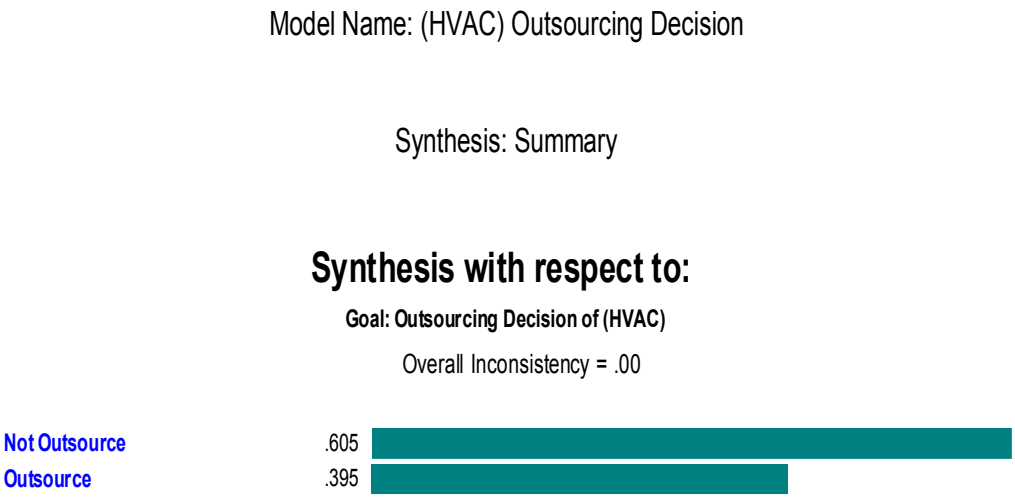


Figure 6.14: Priorities of Alternatives with Respect to (HVAC) Outsourcing Decision

The next step is to perform sensitivity analyses for the alternatives with respect to the factors. Figure (6.15-6.16) shows the sensitivity analysis conducted for the HVAC outsourcing decision.

Figure 6.17 shows the (HVAC) hierarchy model with priorities. As shown, the priority is to not-outsource obtained (60.5%) and outsource alternative obtained (39.5%). This indicates the maintenance department should select the not-outsource alternative that had the highest total weighted score.

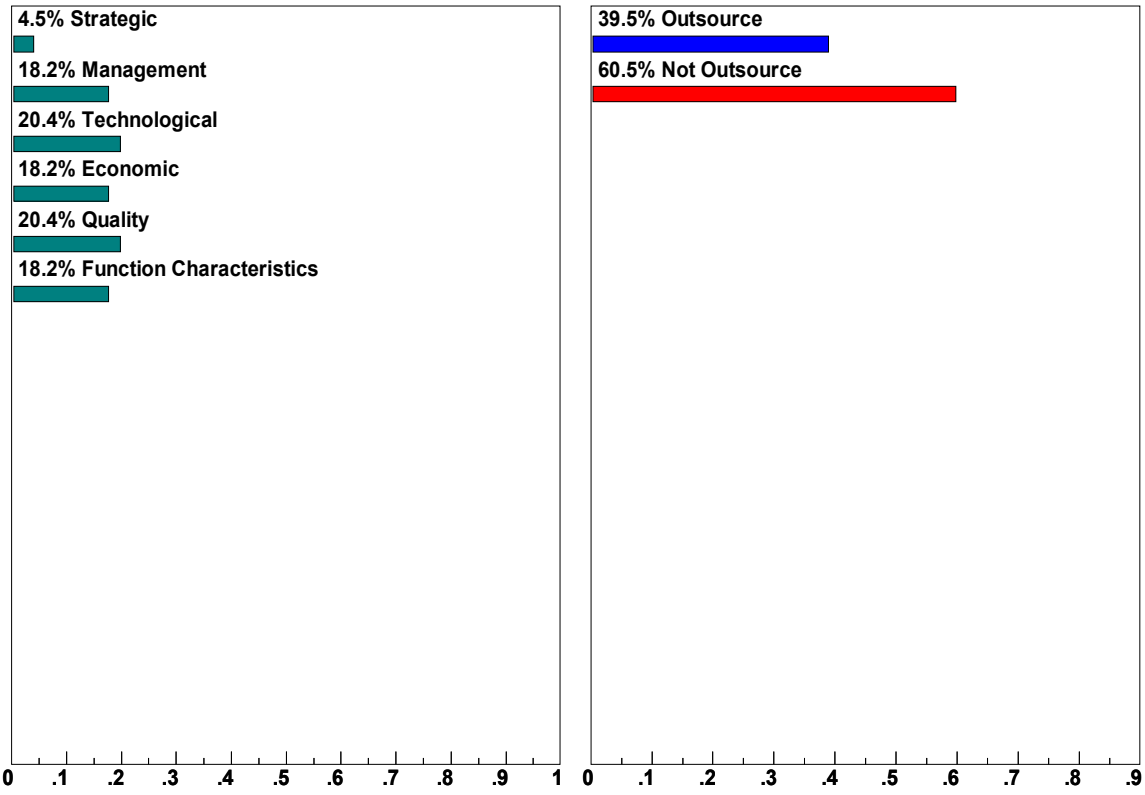


Figure 6.15: Dynamic Sensitivity for HVAC Outsourcing Decision

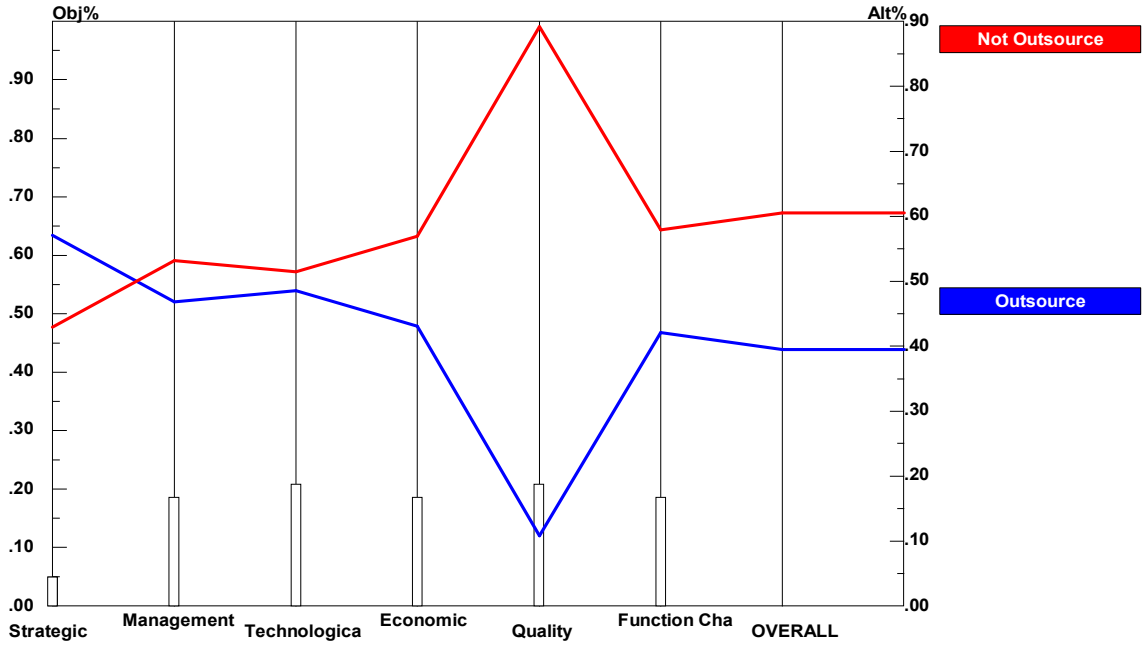


Figure 6.16: Performance Sensitivity for HVAC Outsourcing Decision

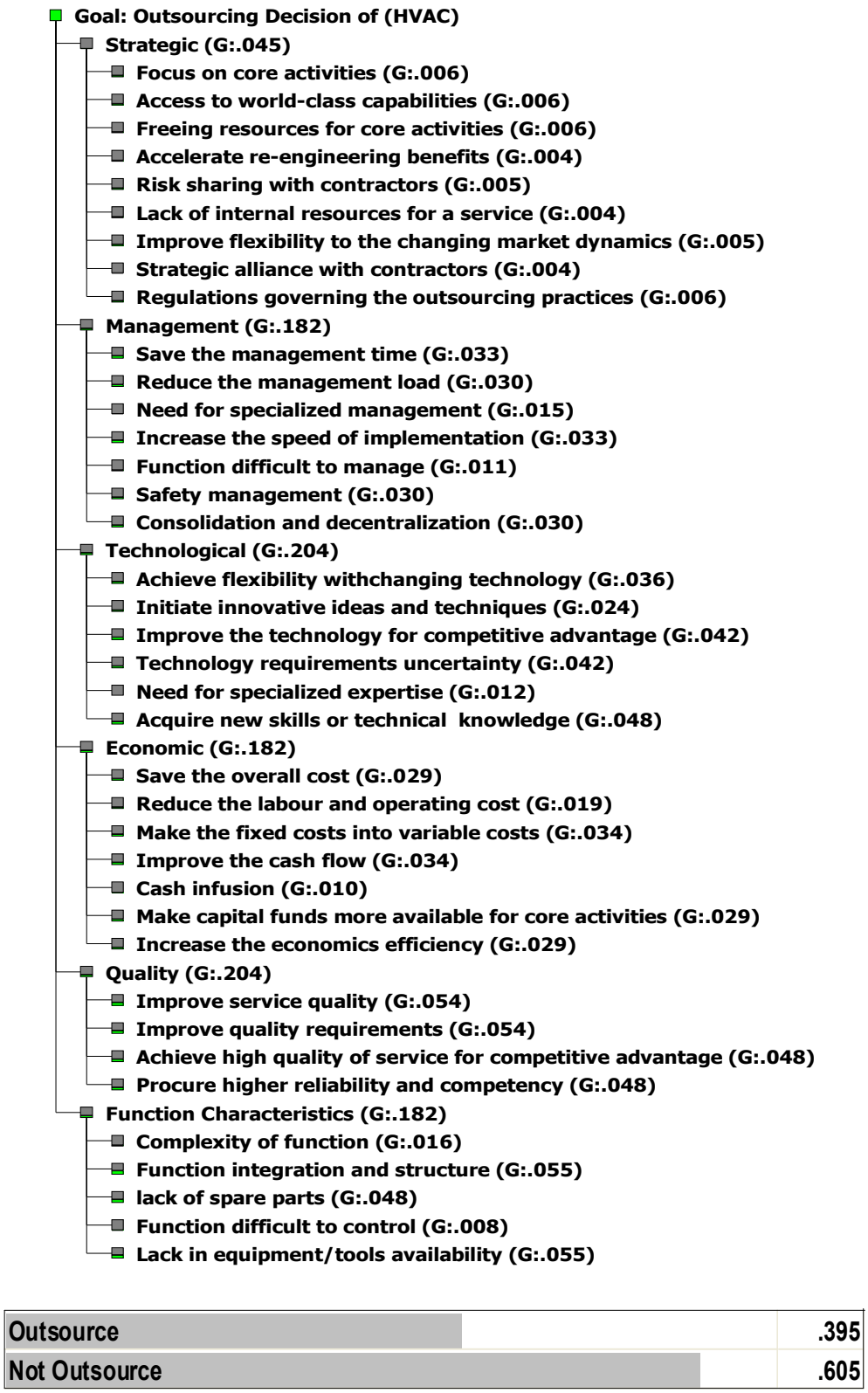


Figure 6.17: (HVAC) Hierarchy Model with Overall Priorities

CHAPTER SEVEN

CONCLUSION AND RECOMMENDATIONS

7.1 Introduction

In this research, the factors of outsourcing decision for maintenance services are studied and the AHP has been utilized as an aided tool for developing the outsourcing decision-making framework for maintenance services in Saudi universities. In this chapter, a summary of research is discussed, followed by conclusions derived from the research and recommendations for future studies.

7.2 Summary of Study

The main objectives of this research were to determine the most important factors for the outsourcing decision and ranking them by identifying and assessing the factors influencing the decision to outsource and developing a decision-making framework.

The methodology consists of four phases. First, the research focused on acquiring the knowledge through extensive literature review. Then, interviews were conducted with two maintenance department managers at King Fahd University of Petroleum and Minerals, and King Faisal University for a pilot study. The interviews resulted in refining the list of factors to include thirty-eight factors classified and grouped under six main categories.

Second, the facilities systems/services requiring maintenance activities and the most influential factors are identified, then the questionnaire were developed for interviews of selected universities. A total of eleven responses were obtained from maintenance departments of eleven Saudi Arabian universities.

Third, the frequency of outsourcing the required maintenance services was assessed. The AHP basic principles and its application steps are utilized for a ranking of the factors. The analysis assisted to determine the most important factors and obtain a ranking of importance.

Finally, the decision-making framework was developed, and the final prioritization was obtained. Case-study on the decision to outsource HVAC systems maintenance at KFUPM was performed to show the applicability of the developed model. Results can be seen in the conclusions section of this chapter.

7.3 Conclusions

The overall results of this research can be summarized as follows:

7.3.1 Outsourced Maintenance Services

- The results of this survey type show that Saudi universities generally outsource their maintenance services to the contractors excluded KFUPM.

- The findings indicate that Saudi universities evaluated the frequency of maintenance services required outsourcing as: fire protection systems, elevator systems, HVAC

systems, electrical systems, housekeeping and waste disposal, major construction & renovation works are always outsourced.

7.3.2 Outsourcing Decision Factors

First part: General Information

- Forty percent (40%) of respondents indicated that the ratio between the costs of outsourcing contracts of maintenance services to the overall costs of maintenance services was over 70 % of costs.

- Seventy three percent (73%) of respondents, who answered the questionnaire, were working as Maintenance Managers, and eighteen percent (18%) of them were working as Maintenance Management Managers.

- Eighteen percent (18%) of respondents, who answered the questionnaire, had over 20 years experience, and thirty seven percent (37%) of respondents had less than 5 years experience in this field.

Second part: Importance of Outsourcing Decision Factors

- The findings also show that Saudi universities generally agree on the importance of the quality and economic factors when making outsourcing decisions. They include the use of outsourcing to improve quality requirements, to save the overall cost.

- The overall importance of the quality category received priority of 18.5%, economic category received priority of 17.1%, strategic category received priority of 16.8%, management category received priority of 16.6%, function characteristics category received priority of 15.8%, and technological category received priority of 15.2%.

- The top three Strategic Factors were identified as follows:

1) Risk sharing with contractors.
2) Improve flexibility to the changing market dynamics.
3) Access to world-class capabilities.

- The top three Management Factors were identified as follows:

1) Increase the speed of implementation
2) Save the management time
3) Need for specialized management

- The top three Technological Factors were identified as follows:

1) Acquire new skills or technical knowledge
2) Achieve flexibility with changing technology
3) Improve the technology for competitive advantage

- The top three Economic Factors were identified as follows:

1) Save the overall cost
2) Reduce the labour and operating cost
3) Improve the cash flow

- The top three Quality Factors were identified as follows:

1) Improve quality requirements
2) Achieve high quality of service for competitive advantage
3) Procure higher reliability and competency

- The top three Function Characteristics Factors were identified as follows:

1) Function integration and structure
2) Lack of spare parts
3) Function difficult to control

- The top ten factors influencing the decision to outsource the maintenance services in Saudi Arabia universities were identified as follows:

1) Improve quality requirements
2) Achieve high quality of service for competitive advantage
3) Procure higher reliability and competency
4) Improve service quality
5) Function integration and structure
6) Lack of spare parts
7) Function difficult to manage and control
8) Save the overall cost
9) Reduce the labour and operating cost
10) Lack in equipment/tools availability

7.3.3 Framework of Outsourcing Decision

- The developed framework gives the user a structured and systematic decision making approach for evaluating and selecting the decision alternatives using AHP due to its ability for taking into account both the qualitative and quantitative measures.

- The result supports the decision to outsource with priority of 77% and not-outsource alternative with a priority of 23%.

7.4 Recommendations

One of the purposes of this research was to provide some recommendations. The recommendations can be summarized as follows:

- The obtained results indicate that Saudi Arabia universities are adopting outsourcing as a goal to achieve higher services quality of maintenance services.

- It is suggested that the scope of this a research should be widened to include all of Saudi Arabia universities.

- It is suggested that a decision framework might help the maintenance departments of universities to make better outsourcing decisions.

- The framework suggests that Saudi universities should consider both quality, economic, and then strategic implications when making outsourcing decisions.

7.5 Recommendations for Future Studies

Some areas in this research need further research, these studies might include:

- The scope of this research takes into account the opinions of maintenance managers and maintenance engineers. Future studies might be conducted using a wider population which includes clients, facility managers, and so on.

- This research is limited to maintenance departments of Saudi universities. It is suggested that the same research can be conducted for private and public organizations of Saudi Arabia.

- Future researches should further develop the decision to outsource to consider additional aspects of the decision including: benefits and risks of outsourcing.

- This research considered a one-method decision making. Future research should consider other methods that are used and are similar to this topic.

- The overlap between some of the factors associated with both the management category and technological category should be taken into consideration in future studies.

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APPENDIX I

Subject: Study on Identifying the Frequency of Outsourcing Maintenance Services at Saudi Universities

Dear Respondent:

A study is being conducted at KFUPM for identifying the maintenance services that are frequently outsourced (contracted out) to specialty contractors. Kindly use the following scale to rate the frequency of outsourcing these maintenance services at your university:

Always = 75-100% Often = 50-75% Sometimes = 25-50% Seldom =0- 25% Never = 0%

Typical Maintenance Activities	Always	Often	Sometimes	Seldom	Never	Remarks
Heating, Ventilation and Air Conditioning System (HVAC)						
Fire Protection Systems						
Elevator Systems						
Plumbing and Sanitary Systems						
Electrical Systems						
Painting (Interior and Exterior of Buildings)						
Major Construction and Renovation Works						
Minor Construction						
Carpentry						
Steel work						
Telecommunication Systems						
Electrical Appliances						
Housekeeping and Waste Disposal						
Landscaping Services						
Other, please specify ……						
Other ……						

الموضوع: دراسة لتحديد نوع خدمات الصيانة التى تعمل بواسطة المقاولين فى الجامعاتِ السعوديةِ

تُجرى هذة الدراسة في جامعة الملك فهد للبترول و المعادن لتحديد نوع خدماتِ الصيانة التي كثيراً ما توجة الى المقاولين لتاديتها.

من فضلك استعمل المِقياسُ التاليُ لتَقدير الترددِ لهذه الخدماتِ في جامعتِكِ:

خدمات الصيانة	دائما	غالبا	احيانا	نادرا	ابدا	الملاحظات
انظمة التهوية والتكييف						
أنظمة الحماية من الحريق						
أنظمة المصاعدِ						
السباكة والأنظمة الصحية						
الأنظمة الكهربائية						
الطلاء داخل وخارج البناياتِ						
أعمال الترميمَ والبناءَ						
أعمال البناء البسيطة						
اعمال النجارة						
الاعمال الفولاذية						
اعمال الانترنت والاتصالات						
العدد الكهربائية						
النظافة و التخلص من النفايات						
خدمات المواقع (المواقف و الساحات)						
اخرى						

APPENDIX II

SUBJECT:

Study of Decision Factors for Outsourcing the Maintenance Services of Saudi Universities

A study is being conducted on decision making for outsourcing of maintenance. The objective of this study is identify the factors affecting the decision of outsourcing for maintenance services in Saudi universities by ranking the most important factor affect on the decision to outsource using the analytic hierarchy process (AHP) method.

The objective of this questionnaire is to seek your opinion about the factors that are essential for the outsourcing decision of maintenance services in Universities.

Your input is required to determine the importance of each factor on the decision of outsourcing and if the list is inclusive or if there are any other factors that need to be added. The impact of each factor on the overall decision based on a scale of 1 to 9 is required. The following table explains the meaning of each point on the scale.

Scale Points	Description
9	Absolutely important
7	Very strongly important
5	Strongly important
3	Weakly important
1	Less important
2,4,6,8	Intermediate values, for example, a value of 8 means that the degree of importance is between very strongly important which is (7) and absolutely important which is (9).

Your input to this questionnaire will lead to a better understanding of the factors that influence the decision for outsourcing of maintenance services.

Example: Put mark ✓ as you see in the Figure bellow, if you see strategic factor as strongly importance for the decision in the cell 5.

Main factors influencing the decision of outsourcing	1	2	3	4	5	6	7	8	9	Remarks
Strategic					✓					

QUESTIONNAIRE

This questionnaire consists of two parts. First part is the respondent's general information. The second part is for pair-wise comparisons. The respondents are specifically reminded of the importance of observing consistency in their answers. Any information obtained through this questionnaire will stringently be used for educational use.

(General Information)

1) Respondent Information

Name (Optional)	
University Name	
Telephone no	
Facsimile	
E-Mail Address,	
University Address.	

2) How many years of experience you have in your work:

a) Less than 5 years		b) 5-10 years	
c) 10-20 years		d) Over 20 years.	

3) Respondent position:

Maintenance Department Manager	
Maintenance Manager	
Others ……..	

4) Outsourcing contracts cost to the cost of maintenance services:

a) Less than 25 %		b) 25-50 %	
c) 50-75 %		d) Over 75%	

Decision Factors for Outsourcing the Maintenance Services of Saudi Universities

Strategic Factors	1	2	3	4	5	6	7	8	9	Remarks
Focus on core activities										
Access to world-class capabilities										
Freeing resources for core activities										
Accelerate re-engineering benefits										
Risk sharing with contractors										
Lack of internal resources for a service										
Improve flexibility to the changing market dynamics										
Strategic alliance with contractors										
Regulations governing the outsourcing practices										
Others……										
Others……										

Decision Factors for Outsourcing the Maintenance Services of Saudi Universities

Management Factors	1	2	3	4	5	6	7	8	9	Remarks
Save the management time										
Reduce the management load										
Need for specialized management										
Increase the speed of implementation										
Function difficult to manage										
Safety management										
Consolidation or decentralization										
Others……										
Others……										
Others……										

Decision Factors for Outsourcing the Maintenance Services of Saudi Universities

Technological Factors	1	2	3	4	5	6	7	8	9	Remarks
Achieve flexibility with changing technology										
Initiate innovative ideas and techniques										
Improve the technology for competitive advantage										
Technology requirements uncertainty										
Need for specialized expertise										
Acquire new skills or technical knowledge										
Others……										
Others……										
Quality Factors										
Improve service quality										
Improve quality requirements										
Achieve high quality of service for competitive advantage										
Procure higher reliability and competency										
Others……										
Others……										

Decision Factors for Outsourcing the Maintenance Services of Saudi Universities

Economic Factors	1	2	3	4	5	6	7	8	9	Remarks
Save the overall cost										
Reduce the labour and operating cost										
Make the fixed costs into variable costs										
Improve the cash flow										
Cash infusion										
Make capital funds more available for core activities										
Increase the economic efficiency										
Others……										
Function Characteristics Factors										
Complexity of function										
Function integration and structure										
lack of spare parts										
Function difficult to control										
Lack in equipment/tools availability										
Others……										

Decision Factors for Outsourcing the Maintenance Services of Saudi Universities

Main Categories	1	2	3	4	5	6	7	8	9	Remarks
Strategic category										
Management category										
Technological category										
Economic category										
Quality category										
Function characteristics category										
Others……										
Others……										
Others……										

Decision Factors for Outsourcing the Maintenance Services of Saudi Universities

Decision Factors	Outsource	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Not Outsource
Focus on core activities																			
Access to world-class capabilities																			
Freeing resources for core activities																			
Accelerate re-engineering benefits																			
Risk sharing with contractors																			
Lack of internal resources for a service																			
Improve flexibility to the changing market																			
Strategic alliance with contractors																			
Regulations governing the outsourcing practices																			
Save the management time																			
Reduce the management load																			
Need for specialized management																			
Increase the speed of implementation																			
Function difficult to manage																			
Safety management																			

Decision Factors for Outsourcing the Maintenance Services of Saudi Universities

Decision Factors	Outsource	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Not Outsource
Consolidation or decentralization																			
Achieve flexibility with changing technology																			
Initiate innovative ideas and techniques																			
Improve the technology for competitive advantage																			
Technology requirements uncertainty																			
Need for specialized expertise																			
Acquire new skills or technical knowledge																			
Improve service quality																			
Improve quality requirements																			
Achieve high quality of service for competitive																			
Procure higher reliability and competency																			
Save the overall cost																			
Reduce the labour and operating cost																			
Make the fixed costs into variable costs																			
Improve the cash flow																			

Decision Factors for Outsourcing the Maintenance Services of Saudi Universities

Decision Factors	Outsource	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	Not Outsource
Cash infusion																			
Make capital funds more available for core activities																			
Increase the economic efficiency																			
Complexity of function																			
Function integration and structure																			
Lack of spare parts																			
Function difficult to control																			
Lack in equipment/tools availability																			
Others……																			
Others……																			
Others……																			

APPENDIX III

بسم الله الرحمن الرحيم

الموضوع:

دراسة العوامل المؤثرة على قرار استخدام مصدر خارجي (مقاولين) لاداء خدماتِ الصيانة في الجامعاتِ السعوديةِ

تهدفَ هذه الدراسةِ إلى تعريف و تقييم العواملَ المؤثرة على قرار استخدام مصدر خارجي (مقاولين) لاداء خدماتِ الصيانة في الجامعاتِ السعوديةِ .

و يهدفَ الاستبيان المرفق إلى معرفة رأيكَم حول العوامل الضرورية وتحديد درجة كل عامل مؤثر على قرار تبني إستراتيجية استخدام مصدر خارجي لاداء خدماتِ الصيانة في الجامعاتِ السعودية.

مساهمتكَ في هذا الاستبيان سَيُؤدّي إلى فَهْم أفضل للعوامل التي تُؤثّرُ على قرار استخدام مصدر خارجي لخدماتِ الصيانة. ونؤكد لكم أن المعلومات لن تستخدم إلا لغرض البحث فقط.

يرجى منكم المساهمة في تقدير أهميةِ كُلّ عامل يؤثر على القرار و إضافة أي عوامل ترونها مناسبة.

تأثير كُلّ عامل على القرار يستند على مِقياس مِنْ 1 إلى 9. الجدول ادناة يوضّحُ معنى كُلّ نقطة على المِقياس.

وزن المِقياسُ	مقياس الأهمية
9	مهم جداً بقوة مطلقة
7	مهم جداً بقوة
5	مهم جداً
3	مهم
1	أقل اهمية
2,4,6,8	ترمز إلى قيم متوسطة بين المقياس السابقة و اللاحقة

هذا الاستبيان يشتمل على جزئيين الجزء الأول معلومات عامة أما الجزء الثاني المعلومات المطلوبة لمقارنة العوامل.

معلومات عامة

الاسم(اختياري)	
الجامعة	
التلفون	
الفاكس	
الايميل	
عنوان الجامعة	

مدة الخبرة في العمل

اقل من 5 سنوات		**من 5 إلى 10 سنوات**	
من 10 إلى 20 سنة		**أكثر من 20 سنة**	

الموقع الوظيفي

مدير أقسام الصيانة	
مهندس الصيانة	
مسمى آخر.....	

نسبة كلفة عقود الصيانة الخارجية الى مجموعة تكاليف الصيانة في الجامعة

اقل من 25 %		**من 25 إلى 50 %**	
من 50 إلى 75 %		**أكثر من 75%**	

العوامل المؤثرة على قرار استخدام الجامعات السعودية لمصدر خارجي (مقاول) لعمل خدمات الصيانة

العوامل الإستراتيجية	1	2	3	4	5	6	7	8	9	الملاحظات
تركيز الجامعة على الخدمة الرئيسية (التعليم)										
الحصول على خدمة متميزة بمعايير عالمية										
توجيه المصادر المتوفرة حاليا للخدمات الرئيسية كالتعليم و خدماته										
الاستفادة السريعة من إعادة هندسة إجراءات العمل(الاستفادة من إعادة الهيكلة الجديدة لقسم الصيانة بالجامعة)										
تقليل الأخطار بالاشتراك مع المقاول (القانونية, المالية, تدهور مستوى الخدمة)										
عدم توفر المصادر اللازمة للقيام بخدمات الصيانة بالجامعة										
إيجاد بيئة عمل تتسم بالمرونة في اداء أعمال الصيانة ملائمة لمتطلبات المستخدم										
القيام بتحالف استراتيجي مع مقاول الصيانة لسد النقص في المصادر و التقنية										
الأنظمة القانونية التي تحكم ممارسة استخدام مصدر خارجي للقيام بخدمات الصيانة										
أخرى.....										
أخرى.....										

العوامل المؤثرة على قرار استخدام الجامعات السعودية لمصدر خارجي (مقاول) لعمل خدمات الصيانة

العوامل الإدارية	1	2	3	4	5	6	7	8	9	الملاحظات
توفير وقت الإدارة من خلال الاداء السريع لخدمات الصيانة										
تخفيف العبء الإداري على قسم الصيانة من خلال الاعتماد المباشر على المقاول للقيام ببعض خدمات الصيانة										
الحاجة لإدارة متخصصة لان المقاول يمتلك الأجهزة و الموظفين المتخصصين لاداء خدمة الصيانة										
القيام بالخدمة بشكل سريع طبقا للوقت المتفق علية في العقد										
الخدمة صعبة الإدارة أو خارجة عن السيطرة بسبب تعقيدها او عدم توفر الموظفين										
إدارة أمنة (تحويل المسؤوليات القانونية للإصابات و الأخطار للمقاولين)										
المرونة في الجامعة و الأقسام يضمن التعزيز و اللامركزية										
أخرى.....										
أخرى.....										
أخرى.....										

العوامل المؤثرة على قرار استخدام الجامعات السعودية لمصدر خارجي (مقاول) لعمل خدمات الصيانة

العوامل التكنولوجية	1	2	3	4	5	6	7	8	9	الملاحظات
تماشي مع سرعة التقنية بتبني التقنيات الحديثة التي يمتلكها المقاول										
تقديم تقنية جديدة وفكرة إبداعية تحل محل العملية القديمة										
تحسين التقنية لاداء خدمة الصيانة للميزة التنافسية										
تفادي التعامل مع تقنية مبهمة لقسم الصيانة										
الحاجة للخبرة المتخصصة التي يمتلكها المقاول في نفس الخدمة										
اكتساب المهارات و التقنية الحديثة عن طريق التعامل مع مقاولين ذوي خبرة										
أخرى.....										
العوامل الجودة (النوعية)										
الحصول على خدمة ممتازة بموصفات عالية										
تحسين متطلبات الجودة (النوعية) في خدمة الصيانة										
تقديم خدمة تنافسية للتكيف مع التغيرات غير المتوقعة و استمرار النوعية العالية										
الحصول على الثقة و الكفاءة في الخدمة التي تقدمها الجامعة										
أخرى.....										

العوامل المؤثرة على قرار استخدام الجامعات السعودية لمصدر خارجي (مقاول) لعمل خدمات الصيانة

العوامل الاقتصادية	1	2	3	4	5	6	7	8	9	الملاحظات
توفير الكلفة الإجمالية (هدف الجامعة لتخفيف كلفة الصيانة)										
تخفيف كلفة الأيدي العاملة و التشغيل										
التحول من الكلفة الثابتة (الرواتب وكلف التشغيل) لتصبح متغيرة										
الموقف المالي لقسم الصيانة										
دعم مالي ناتج عن بيع الأجهزة و المعدات للمقاول كجزء من الصفقة										
توفير الأموال المدخرة من تبني إستراتيجية استخدام مقاول للخدمات الرئيسية										
الكفاءة الاقتصادية الناتجة من وفرة حجم الآليات المستعملة لانجاز هذا المستوى										
عوامل خصائص الخدمة										
تعقيد الخدمة و صعوبة فهم التغيرات و التوقعات المحيطة										
تكامل الخدمة وتركيبها (ارتباطها مع خدمات أخرى)										
قلة قطع الغيار (توفرها وبعد السوق)										
صعوبة السيطرة على الخدمة (التوقعات أو صعوبة الإدارة الغير واضحة)										
قلة في الأجهزة و المعدات المطلوبة للخدمة										
أخرى.....										

العوامل المؤثرة على قرار استخدام الجامعات السعودية لمصدر خارجي (مقاول) لعمل خدمات الصيانة

العوامل المؤثرة على قرار استخدام مصدر خارجي لأداء خدمة الصيانة	1	2	3	4	5	6	7	8	9	الملاحظات
عوامل إستراتيجية (الأهداف طويلة المدى للجامعة)										
العوامل الإدارية المؤثرة على اداء خدمة الصيانة										
العوامل التكنولوجية المطلوبة للحصول على خدمة عالية										
العوامل الاقتصادية التي تهدف الجامعة لانجازها										
عوامل الجودة المؤثرة على نوعية الخدمة										
عوامل خصائص (سمات) خدمة الصيانة										
أخرى.....										
أخرى.....										

العوامل المؤثرة على قرار استخدام الجامعات السعودية لمصدر خارجي (مقاول) لعمل خدمات الصيانة

العوامل المؤثرة على قرار استخدام مصدر خارجي لأداء خدمة الصيانة	مصدر خارجي Outsource	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	داخليا Not) (Outsource
تركيز الجامعة على الخدمة الرئيسية (التعليم)																			
الحصول على خدمة متميزة بمعايير عالمية																			
توجيه المصادر المتوفرة حاليا للخدمات الرئيسية كالتعليم و خدماته																			
الاستفادة السريعة من إعادة هندسة إجراءات العمل																			
تقليل الأخطار بالاشتراك مع المقاول (القانونية, المالية, تدهور مستوى الخدمة)																			
عدم توفر المصادر اللازمة للقيام بخدمات الصيانة بالجامعة																			
إيجاد بيئة عمل تتسم بالمرونة في اداء أعمال الصيانة ملائمة لمتطلبات المستخدم																			
القيام بتحالف استراتيجي مع مقاول الصيانة لسد النقص في المصادر و التقنية																			
الأنظمة القانونية التي تحكم ممارسة استخدام مصدر خارجي للقيام بخدمات الصيانة																			
توفير وقت الإدارة من خلال الاداء السريع لخدمات الصيانة																			
تخفيف العبء الإداري على قسم الصيانة من خلال الاعتماد المباشر على المقاول																			
الحاجة لإدارة متخصصة لان المقاول يمتلك الأجهزة و الموظفين لاداء خدمة الصيانة																			
القيام بالخدمة بشكل سريع طبقا للوقت المتفق علية في العقد																			
الخدمة صعبة الإدارة أو خارجة عن السيطرة بسبب تعقيدها او عدم توفر الموظفين																			
إدارة أمنة (تحويل المسؤوليات القانونية للإصابات و الأخطار للمقاولين)																			

العوامل المؤثرة على قرار استخدام الجامعات السعودية لمصدر خارجي (مقاول) لعمل خدمات الصيانة

العوامل المؤثرة على قرار استخدام مصدر خارجي لأداء خدمة الصيانة	مصدر خارجي Outsource	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	داخليا Not) (Outsource
المرونة في الجامعة و الأقسام يضمن التعزيز و اللامركزية																			
تماشي مع سرعة التقنية بتبني التقنيات الحديثة التي يمتلكها المقاول																			
فكرة إبداعية جديدة تحل محل العملية القديمة تقديم تقنية																			
تحسين التقنية لاداء خدمة الصيانة للميزة التنافسية																			
تفادي التعامل مع تقنية مبهمة لقسم الصيانة																			
الحاجة للخبرة المتخصصة التي يمتلكها المقاول في نفس الخدمة																			
اكتساب المهارات و التقنية الحديثة عن طريق التعامل مع مقاولين ذوي خبرة																			
توفير الكلفة الإجمالية (هدف الجامعة لتخفيف كلفة الصيانة)																			
تخفيف كلفة الأيدي العاملة و التشغيل																			
التحول من الكلفة الثابتة (الرواتب وكلف التشغيل) لتصبح متغيرة																			
الموقف المالي لقسم الصيانة																			
دعم مالي ناتج عن بيع الأجهزة و المعدات للمقاول كجزء من الصفقة																			
توفير الأموال المدخرة من تبني إستراتيجية استخدام مقاول للخدمات الرئيسية																			
الكفاءة الاقتصادية الناتجة من وفرة حجم الآليات المستعملة لانجاز هذا المستوى																			
الحصول على خدمة صيانة بموصفات عالية																			

العوامل المؤثرة على قرار استخدام الجامعات السعودية لمصدر خارجي (مقاول) لعمل خدمات الصيانة

العوامل المؤثرة على قرار استخدام مصدر خارجي لأداء خدمة الصيانة	مصدر خارجي Outsource	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	داخليا Not) (Outsource
تحسين متطلبات الجودة (النوعية) في خدمة الصيانة																			
تقديم خدمة تنافسية للتكيف مع التغيرات غير المتوقعة و استمرار النوعية العالية																			
الحصول على الثقة و الكفاءة في الخدمة التي تقدمها الجامعة																			
تعقيد الخدمة و صعوبة فهم المتغيرات و التوقعات المحيطة																			
تكامل الخدمة وتركيبها (ارتباطها مع خدمات أخرى)																			
قلة قطع الغيار (توفرها وبعد السوق)																			
صعوبة السيطرة على الخدمة																			
قلة في الأجهزة و المعدات المطلوبة للخدمة																			
أخرى.....																			
أخرى.....																			
أخرى.....																			
أخرى.....																			
أخرى.....																			