APPLICATION OF MULTI-CRITERIA DECISION MAKING METHOD IN SELECTION OF ACADEMIC STAFF AT FACULTY OF SCIENCE, UNIVERSITI TEKNOLOGI MALAYSIA

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To my beloved father, mother, brothers, sister, and friends

With love and much thanks.

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ABSTRACT

The selection of academic staff is important process for the university because the decision will affect the quality and the success of the university. Academic staff is the professional career as they are person who have the high skills in their respective fields. It is not easy for the selection committee to select appropriate personnel as they always faces up to uncertainty decision making process. Two Multiple Criteria Decision Making (MCDM) method namely Analytic Hierarchy Process (AHP) and Elimination and Choice Translating Reality I (ELECTRE I) are adopted to enable the decision makers to make effective decision in selecting academic staff. Both methods helps permit pair-wise comparison judgments in expressing the relative priority for criteria and alternatives that is translated from qualitative to quantitative data by considering the criteria that influence decision made. This study has applied six main criteria and fifteen sub-criteria for selecting the best one amongst seven candidates for the academic staff position in the Faculty of Science, UTM. The selection criteria of Academic, General Attitudes, Interpersonal Skill, Experience, Extracurricular Activities, and Referees Report that used in this study are determined based on some literature reviews and knowledge acquisition by interview Deputy Registrar from Registrars' Office and Assistant Registrar from Faculty of Science, UTM. By applying both methods, Candidate 7 should be selected as academic staff since she possesses the first rank of the generated candidate profile. Expert Choice 11.0 and Microsoft Excel 2007 are used to assist in accomplishing the calculation involved. As a suggestion for future work, other researches could apply the other of MCDM method in selecting academic staff.

ABSTRAK

Pemilihan kakitangan akademik adalah proses penting bagi universiti kerana keputusan pemilihan akan memberi kesan kepada kualiti dan kejayaan sesebuah universiti. Kakitangan akademik adalah kerjaya profesional kerana mereka mempunyai kemahiran yang tinggi dalam bidang masing-masing. Sukar bagi jawatankuasa pemilihan memilih kakitangan yang sesuai kerana mereka menghadapi ketidakpastian dalam proses pemilihan. Dua kaedah dalam Membuat Keputusan Pelbagai Kriteria (MCDM), dinamakan Proses Hierarki Analisis (AHP) dan Penghapusan dan Pilihan Penterjemahan Realiti I (ELECTRE I) membolehkan pembuat keputusan membuat keputusan berkesan dalam pemilihan kakitangan akademik. Kedua-dua kaedah ini membantu meningkatkan kaedah sedia ada dengan perbandingan penilaian berpasangan dengan menyatakan keutamaan relatif bagi kriteria dan alternatif dari kualitatif kepada kuantitatif dengan mempertimbangkan kriteria yang mempengaruhi keputusan. Kajian ini telah menggunakan enam kriteria utama dan lima belas sub-kriteria untuk memilih calon yang terbaik jawatan kakitangan akademik di Fakulti Sains, UTM. Kriteria pemilihan adalah Akademik, Sikap, Kemahiran Interpersonal, Pengalaman, Aktiviti Kurikulum, dan Laporan Pengadil digunakan dalam kajian ini adalah ditentukan berdasarkan ulasan sorotan kajian dan pemerolehan pengetahuan menemuramah Timbalan Pendaftar di Pejabat Pendaftar dan Penolong Pendaftar dari Fakulti Sains, UTM. Aplikasi dari kedua-dua kaedah, Calon 7 dipilih sebagai kakitangan akademik. Expert Choice 11.0 dan Microsoft Excel 2007 digunakan bagi membantu pengiraan. Cadangan kerja penyelidikan seterusnya, kajian boleh menggunakan lain MCDM dalam memilih kakitangan akademik.

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LIST OF ABBREVIATIONS

AHP	-	Analytic Hierarchy Process
ELECTRE	-	Elimination And Choice Translating Reality
MCDM	-	Muti-Criteria Decision Making
MADM	-	Muti-Attribute Decision Making
MODM	-	Multi-Objective Decision Making
WSM	-	Weighted Sum Model
WPM	-	Weighted Product Model
MAUT	-	Multi-Attribute Utility Theory
CR	-	Consistency Ratio
CI	-	Consistency Index
ADC	-	Academic
ATTD	-	General Attitude
SKILL	-	Interpersonal Skill
EXP	-	Experiences
ACTV	-	Extracurricular Activities
RFR	-	Referees Report
EDU	-	Education Background
CFD	-	Self Confident
RNP	-	Research & Publication
KNW	-	General Knowledge
AGE	-	Age
APR	-	Appearance
CMC	-	Communication Skill

TCH	-	Teaching Skill
ENG	-	Ability Communicate English
TEXP	-	Teaching Experience
WFE	-	Working Field Experience
WDE	-	Working Duration Experience
PAA	-	Participation In Activities
POA	-	Position In Activities
AWD	-	Award

LIST OF SYMBOLS

C_n	-	n Criteria
a_{ij}	-	Element in a matrix, judgment on pair of criteria C_i, C_j
W_i	-	Weights
A	-	Matrix A
x_n	-	Relative importance by n experts
W	-	Matrix W, Eigenvector
w_1, w_2, w_3	-	Weight (element w)
p_j	-	Weight of the j sub-criteria
q_{ij}	-	Priority weights of the i candidates on the j sub-criteria

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Operational research is an important area of mathematics. Operational research is the application of advanced analytical methods to help make better decision. The important of operations research is the development of approaches for optimal decision making. Decision making is the study of identifying and choosing alternatives based on the values and preferences of the decision maker. Making a decision implies that there are alternative choices to be considered, and in such a case we want not only to identify as many of these alternatives as possible but to choose the one that best fits with our goals, objectives, desires, values, and so on (Harris, 1988).

Decision making process should start with the identification of the decision makers and stakeholders in the decision, reducing the possible disagreement about problem definition, requirements, goals and criteria (Baker et al, 2002). Personnel selection is the process of choosing individuals who match the qualification required to perform a defined job in the best way (Dursun and Karsak, 2010). A very common problem in the personal selection is that the biases of those the rating have a tendency to creep into the selection process (Arvey and Campion, 1982).

As in many decision problems, personnel selection such as academic staff selection is very complex in real life. Academic staff selection is an important process for the universities as this decision affects the quality of education and the success of the university. Selection committee faces up to the uncertainty and vagueness in the decision making process (Ertugrul and Karakasoglu, 2007). In this study, Multi-Criteria Decision Making (MCDM) methods can be applied to decision making in this areas. By using MCDM method, uncertainty and vagueness from subjective perception and the experiences of decision maker can be effectively represented and reached to be more effective decision.

There are a lot of MCDM available methods in the decision making areas. Each one of them has its own features. In this study, the two types of MCDM method namely Analytic Hierarchy Process (AHP) and Elimination and Choice Translating Reality I (ELECTRE I) can be applied in academic staff selection. The AHP and ELECTRE I method applied in this study to prove that both method shows the similarity results (Salomon, 2001). As academic staffs are related to the success and failure of higher education institutions, well developed selection criteria can signify the essential element of the position, attract a high quality pool of applicants and provide a reliable standard that applicants can be considered against (Khim, 2009).

The selection committee follows the recruiting process should provide reliable and valid information about job applicants. It is crucial that everyone in the selection committee understand the list of selection criteria and use it as the focal point throughout candidate assessment. Essential criteria are those teaching skills, past experiences, qualifications, abilities and publications and researches that are relevant to the performance of the functions of a person's duties. The selection criteria provide structure to assist the selection committee in developing effective interview questions and in identifying the applicants to measure their own suitability (Khim, 2009).

Academic staff selection is a multiple criteria decision making problem which is refers to making decisions in the presence of multiple, usually conflicting criteria (Zanakis et al, 1998). A MCDM method, as its own name suggests is for use in situations when more than one criterion must be considered. It is one of the well-known topics of decision making. MCDM problems are commonly categorized as continuous or discrete, depending on the domain of alternatives. The problems of MCDM can be classified into two categories: Multiple Attribute Decision Making (MADM) and Multiple Objective Decision Making (MODM), depending on whether the problem is a selection problem or a design problem.

1.2 Background of the problem

One of the applications of MCDM in the area of operational research is the selection of employees. The selection of employees is very important to ensure the success and effectiveness of an institution. Employee selection is a process that consists of recruiting, interviewing and selecting the best employees. The goal of employee selection is to choose the most competent person for the position by obtaining and carefully reviewing all relevant information. Usually, the most typical problem is the selection of the best candidates. Relevant information should be emphasized to ensure the right person is selected.

Career as academic staff in an academic institution is the professional career as they are experts who have the high skills in their respective fields. Academic staff is responsible to produce individuals who are able to contribute their services to religion, race and nation. The selection of academic staff for the universities is very important process because the decision will affect the quality and the success of the university. To make a decision we need to know the problem, the need and purpose of the decision, the criteria of the decision, their sub-criteria, stakeholders and groups affected and the alternative actions to take (Saaty, 2008).

Multi-Criteria Decision Making (MCDM) is a branch of decision making. MCDM is all about making choices in the presence of multiple conflicting criteria. This method uses numeric techniques to help decision makers choose among a discrete set of alternative decisions. This is achieved on the basis of the impact of the alternatives on certain criteria and thereby on the overall utility of the decision maker. MCDM research in the 1970s focused on the theoretical foundations of multiple objective mathematical programming and on procedures and algorithms for solving multiple objective mathematical programming problems (James, 2008).

According to Zanakis et al (1998), MCDM problems are commonly categorized as continuous or discrete, depending on the domain of alternatives. Multiple Attribute Decision Making (MADM), with discrete usually limited, number of prespecified alternatives, and involving implicit or explicit tradeoffs. While, Multiple Objective Decision Making (MODM) have decision variable values that are determined in a continuous or integer domain, with either an infinitive or a large number of choices, the best of which should satisfy the decision maker's constraints and preference priorities (Hwang and Yoon, 1981).

In this study, we focus on MADM that is used in a finite 'selection' or 'choice' problem. The two method of MADM used in this study are Analytic Hierarchy Process (AHP) and Elimination and Choice Translating Reality I (ELECTRE I) method. AHP first presented by Thomas L. Saaty (Saaty, 1987) is a MCDM method and is structured using sets of pair-wise comparisons in a matrix to derive both the relative weights of the individual decision criterion and the rating of options in terms of each of the criteria. It aims providing the decision maker a precise reference for adequately making decision and reducing the risk of making wrong decision through decomposing the decision problem into a hierarchy of more easily which can be evaluated independently (Zolfani, 2012).

ELECTRE method was developed by Bernard Roy in the mid-1960s in Europe (Figueira et al, 2005). This method is based on the study of outranking relations using concordance and discordance indexes to analyze such relation among the alternatives. The concordance and discordance indexes can be viewed as measurements of dissatisfaction that a decision maker uses in choosing one alternative over the other (Rouyendegh and Erkan, 2012). Moreover, it has the ability to handle both quantitative and qualitative judgments. On the other hand, it is a rather complex decision making method and requires a lot of primary data (Papadopoulus, 2011).

According to Zanakis et al (1998), their paper stated that it is impossible or difficult to answer questions such as (i) Which method is more appropriate for what type of problem? (ii) What are the advantages or disadvantages of using one method over another? and (iii) Does a decision change when using different methods?. They stated that the major criticism of MADM methods is that different techniques yield similar results when applied to the same problem. Based on this statement, this study are develop to applied MADM method namely AHP and ELECTRE I method in selection of academic staff to prove that both MADM method yield similar result by using different methods.

The solutions obtained by different MADM methods are essentially the same. Belton (1986) concluded that AHP and a Simple Multi-Attributed Value Function are the approaches best suited and the most widely used in practice. Goicoechea et al (1992), determine the relative utility and effectiveness of MCDM models for applications in realistic water resources planning settings. Based on a series of nonparametric statistical tests, the results identified Expert Choice for AHP method as the preferred MCDM model based largely on ease of use and understandability. The different additive utility models produce generally different weights, but predicted equally well on the average (Schoemaker and Waid, 1982).

The traditional personnel selection method uses an experimental and statistical techniques approach. After using the experimental approach, decision makers select personnel hinge on their experiences and understanding of the job specifications. In the statistical techniques approach, decision makers finalize their decision through the arrangement of test scores and the measure of accomplishment for the candidate. Interviewing the related candidates is one of the techniques concerning the personnel selection (Yusuff et al, 2012).

Selection of academic staff in university, particularly UTM, has been done using a guideline outlined by the Registrar Office and adapted by the various departments in various faculties in university. Even though the selection process adopted by the departments of the faculties to include elements of quantitative evaluation as well as some qualitative. However, it does not use any standardized or established selection model customized for the university. By applying both AHP and ELECTRE I method in selection of academic staff, it can help standardized selection model in the university.

1.3 Statement of the problem

This study will develop the selection model of academic staff at the Faculty of Science, UTM by using MCDM methods, namely Analytic Hierarchy Process (AHP) and Elimination and Choice Translating Reality I (ELECTRE I) method.

1.4 Objectives of the study

The objectives of the research are:

1. To identify the criteria that will affect the selection process of academic staff of Faculty Sciences in UTM.
2. To develop the AHP and ELECTRE I model in academic staff selection.
3. To compare the result obtain from AHP and ELECTRE I method in selection of academic staff.

1.5 Scope of the study

In this research, the attention is focused on the application of AHP and ELECTRE I as tools for academic staff selection in Faculty Sciences, UTM. There are several criteria considered to the selection decision used in the ranking of the academic staff selection problem.

The profiles of candidates used in simulation of the selection model developed are simulated data. The collection and information of actual profile of those who has holding the posts of academic staff and those who are potential candidates for this position, is not done. This is because due to the sensitivity of the data involved.

Microsoft Excel 2007 software is used in this study for synthesizing the pair-wise comparison matrices and used for calculation of ELECTRE I method. Expert Choice software will be used in this study for applying the AHP method. This software provides a structured approach and proven process for prioritization and decision making. It help decision makers get the best result.

1.6 Significance of the study

From this study, it is hope that we can select the most appropriate academic staff in Faculty of Science, UTM. Other than that, this study will contribute to more effective decisions in the process of selection academic staff in Faculty of Science, UTM. This effectiveness is achieved through the application of AHP and ELECTRE I using decision making process. The MCDM method will provide support to the process of decision making in problems that are too complex to be solve such as in this study the selection process for academic staff at the university. The best performance of MCDM method will be the most suitable method to apply for selection of academic staff in Faculty of Science, UTM.

1.7 Thesis Organization

This dissertation consists of six chapters. In Chapter 1, an overview of this study has been addressed. In this chapter, we include the background of the study, objectives of the study, scope, and the significance of the study.

Chapter 2 focuses on the literature review. This chapter describes the academic staff selection problem and the criteria for the selection process. There are also has explanation on application of MCDM method by different researchers.

In Chapter 3, we describe the methodology adopted in this study. This chapter presented the AHP and ELECTRE I aided selection model developed in this study. The selection criteria and sub-criteria are determine and the priority weights synthesize are discussed in this chapter.

Chapter 4 details the application of AHP and ELECTRE I method in the academic staff selection process in Faculty of Science, UTM. This chapter shows the use of Expert Choice 11.0 and Microsoft Excel 2007 software. The calculations involved are shown in detail.

Chapter 5 presents the ranking of candidates in order to select the best candidate for the faculty by using Microsoft Excel 2007 and Expert Choice 11.0 software.

In Chapter 6, we states the summary and conclusion of this research based on the results that we showed in Chapter 5. Then, there are some suggestion and recommendations for future researchers.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter presents the literature review for the research understudied. It starts with discussion on the general idea about academic staff selection, Multiple Criteria Decision Making (MCDM), Analytic Hierarchy Process (AHP) and Elimination and Choice Translating Reality (ELECTRE). The primary purpose of this study is to discusses details about MCDM, AHP, and ELECTRE I and the application of this method to academic staff selection. The details about these methods will be discussed in the next section in this chapter.

2.2 Academic Staff Selection Problem

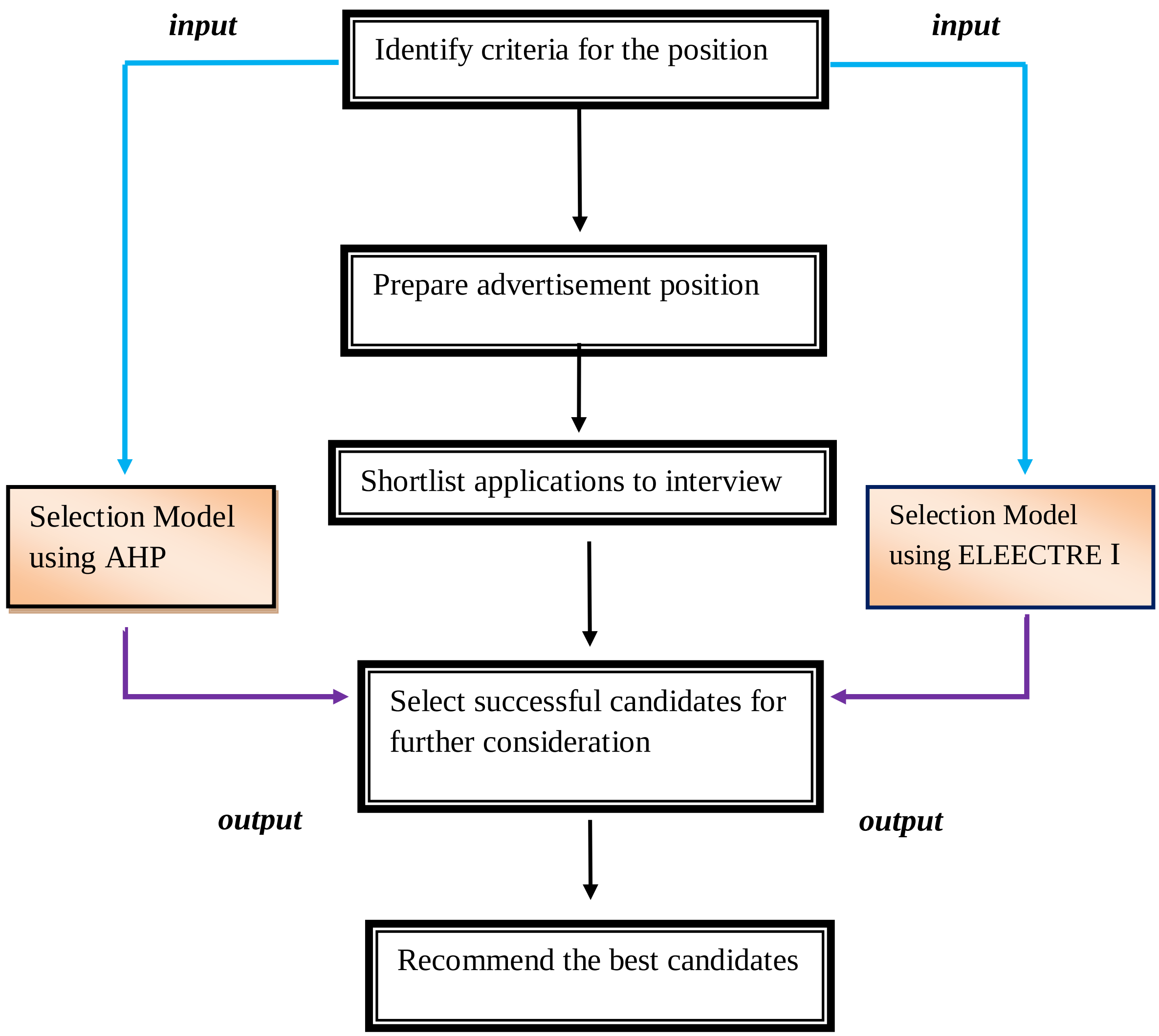
The traditional employee evaluation and selection process uses an experimental and statistical techniques approach that decision-makers select upon their understanding of the job specifications and the individuals who have been successful in the preliminary selection, in which the process generally has individual biases and stereotypes (Golec and Kahya, 2007). It is not easy for the decision makers to select appropriate personnel who satisfy all the requirements among various criteria that is affected by several conflicting factors and it consists of both qualitative and quantitative factors

(Rouyendegh and Erkan, 2012). Therefore, there exists multiple criteria decision-making model to ensure an acceptable and efficient selection process.

According to Khim (2009), her study embarks on finding out the potential criteria and developing an AHP aided decision making model for the academic staff selection process. Yang and Shi (2002), presents an application of the AHP in firms' long-term overall performance evaluation through a case study in China and it shows that AHP application can assist managers to effectively evaluate firm's overall performance in their long-term strategic planning process even under complex economic and marketing conditions. Afshari et al (2010) in their study considers a real application of personal selection with using the opinion of experts by one of the group decision making model called ELECTRE method.

The selection process is the critical process to ensure the right candidates are selected by choosing the most suitable and qualified candidates and has potential to success in their jobs. Academic staff selection is a multi-criteria decision making process and a strategic importance for most universities. Staff recruitment is one of the primary steps in the process of universities' human resources and education management (Rouyendegh and Erkan, 2012).

The selection of academic staff starts with the selection committee identifying the assessment criteria for the candidates that required for this position. The importance for each criterion are varying from other criterion. The priority of each criterion needs to be determined. Then, the selection committee prepares the advertisement for the position to be filled. Selection committees will shortlist applications to interview applicants for employment based on the qualification. The successful candidates will be selected as the academic staff position for further consideration. In this process of selecting academic staff, the application of AHP and ELECTRE I will be applied. The committee selection will recommend the best candidates based on the MCDM method performed. The detail procedures or flow charts for academic staff selection process to select the appropriate candidates are summarized as shown in Figure 2.1.



Flow of Information	Description
	The processed information being used as critical aid in the decision making process (output)
	The input of relevant information into the selection model developed

Figure 2.1 Academic Staff Selection Process

2.2.1 Selection criteria

In this study, to determine the most eligible individual for an academic staff position several decisive factors were classified. According to Rouyendegh and Erkan (2012), the factors are classified into three main criteria such as work factors, academic factors and individual factors. These criteria divided into various sub-criteria. The work factors will divide into foreign language, bachelor degree and oral presentation. While for academic factor is divide into academic experiences, research paper, technical information and teamwork. The individual factors divide into self-confidence, compatibility and age.

According to Formann (1992), by using some criteria for each applicant such as adequacy of field of work, age, and number of publications, this scaling procedure results in weights for each of the categories of the criteria indicating the relative importance of each criterion. However, the importance of the different criteria looks rather discrepant if measured by the difference of the extreme categories of each criterion. Age, year of habilitation, and actual academic position are more important than adequacy of field of work publications, and stays abroad.

Afshari and Mojahed (2010) in their paper apply ability to work, past experiences, team player, and fluency in a foreign language, strategic thinking, oral communication and computer skills as qualitative criteria for personnel selection. Personnel selection depending on the firm’s specific targets and individual preferences of decision makers is a highly complex problem.

As described by Golec and Kahya (2007), for each goal we need to analyze what employee characteristics relate to that goal. Those factors that related with the job are communication skills, personal traits and self-motivation, interpersonal skills, decision-making ability, technical knowledge base skills, career development aspiration and management skills are considered as selection factors.

2.3 Multiple Criteria Decision Making (MCDM)

Multi-Criteria Decision Making (MCDM) is a well known branch of decision making in the general class of operations research models which deal with decision problems under the presence of a number of criteria (Pohekar and Ramachandran, 2004). MCDM methods are widely used to rank real world alternatives with respect to several competing criteria (Yang, 2012). The MCDM problem is to find an optimal solution, based on multiple and criteria from all feasible alternatives.

MCDM problems can be classified into two main categories. The two main categories is Multiple Attribute Decision Making (MADM) and Multiple Objective Decision making (MODM). This category is based on the different purpose and different data types. That is, we have deterministic, stochastic, or fuzzy MADM methods (Triantaphyllou, 1998). Each method has its own characteristics. There may be combinations of the above methods. This method can be classified as single or group decision making depend on number of decision makers. In MODM, the alternatives are not predetermined but instead a set of objective functions is optimized subject to a set of constraints (Pohekar, 2004). In general, MODM method applies to multi-objective problems that will solve continuous alternatives.

Multi-Attribute Decision Making is the most well known branch of decision-making. It is a branch of a general class of Operations Research models, which deal with decision problems under the presence of a number of decision criteria (Triantaphyllou, 1998). The MADM method will solve discrete alternatives with small number of criteria. MADM will choose the better ones after compare pair of alternatives with respect to each attribute based on some rules. A small number of alternatives are to be evaluated against a set of attributes, which are often hard to quantify. Each MADM problem is associated with multiple attributes. Attributes are also referred to as "goals" or "decision criteria" (Triantaphyllou, 1998).

Charilas et al (2009) apply Fuzzy AHP and ELECTRE method to network selection. Fuzzy AHP, a MADM method, is initially applied to determine the weights the criteria impacting the decision process. Afterwards, ELECTRE, a ranking MADM method is applied to rank the alternatives in this case wireless networks based on their overall performance. Amiri et el (2008) providing a new and unique method to rank the alternatives with interval data by developing a new ELECTRE method with interval data in MADM problems. Hatami and Tavana (2011) propose an alternative fuzzy outranking method by extending the ELECTRE I method to take into account the uncertain, imprecise and linguistic assessments provided by a group of decision makers. Rouyendegh and Erkan (2011) deals with actual application of academic of staff selection using the opinion of experts to be applied into a model of group decision making called the Fuzzy ELECTRE method.

Salomon and Montevechi (2001) in their paper describe some comparisons on the Analytic Hierarchy Process (AHP) and others Multiple Criteria Decision Making (MCDM) methods based on supplier selection decision making. The comparison between AHP with ELECTRE I and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), considered that AHP assure the consistency analysis of the judgments and more robust than the others two method. The TOPSIS was considered the more simple of the studied methods. The results gotten for the different MCDM methods in the most of cases considered are similar. As a conclusion, they suggest the use of the AHP for expecting the attainment of good results, an excellent and maybe the optimum solution.

Several other field studies have compared ELECTRE to one or more of the other methods. Karni et al. (1990) concluded that ELECTRE, AHP and Simple Additive Weighting (SAW) rankings did not differ significantly in three real life case studies. Lootsma (1990) contrasted AHP and ELECTRE as representing the American and French schools in MCDM thought found to be unexpectedly close to each other. Gomes (1989) compared ELECTRE to TODIM (a combination of direct rating, AHP weighting and dominance ordering rules) on a transportation problem and concluded that both methods produced essentially the same ranking of alternatives. Our major objective was to conduct an extensive numerical comparison of several MCDM methods, contrasted in several field studies, when applied to a common problem and determine when and how their solutions differ.

A list of popular MCDM methods which are used mostly in practice today includes Weighted Sum Model (WSM), Weighted Product Model (WPM), Analytic Hierarchy Process (AHP), Multi-Attribute Utility Theory (MAUT), Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) and Elimination And Choice Translating Reality (ELECTRE). The types of MCDM method will discussed in following section.

2.3.1 Weighted Sum Model (WSM)

According to Triantaphyllou (1998), the weighted sum model (WSM) is the earliest and probably the most widely used method especially in single dimensional problems. If there are M alternatives and N criteria then, the best alternative is the one that satisfies the following expression:

$$P_{WSM}^{*} = \max_{M \geq i \geq 1} \sum_{i=1}^{N} a_{ij} w_j \tag{2.1}$$

where P_{WSM}^{*} is the WSM priority score of the best alternative, a_{ij} is the measure of performance of the ith alternative in terms of the jth decision criterion, and w_j is the weight of importance of the jth criterion.

The WSM method can be applied without difficulty in single dimensional cases where all units of measurement are identical because of the additivity utility assumption, a conceptual violation occurs when the WSM is used to solve multidimensional problems in which the units are different.

2.3.2 Weighted Product Model (WPM)

Triantaphyllou, Shu, Sanchez, and Ray (1998), stated that the Weighted Product Model (WPM) can be considered as a modification of the WSM. The WPM use multiplication to rank alternatives. Each alternative is compared with others by multiplying a number of ratios, one for each criterion. Each ratio is raised to the power of the relative weight of the corresponding criterion. Generally, in order to compare the two alternatives A_k and A_L, the following formula is used

$$R\left(\frac{A_K}{A_L}\right) = \prod_{j=1}^{N}\left(\frac{a_{Kj}}{a_{Lj}}\right)^{w_j} \tag{2.2}$$

where, N is the number of criteria, a_{ij} is the actual value of the *i-th* alternative in terms of the *j-th* criterion, and w_j is the weight of importance of the *j-th* criterion.

If the above ratio is greater than or equal to one, then the conclusion is that alternative A_K is better than alternative A_L. Obviously, the best alternative A* is the one which is better than or at least as good as all other alternatives. The WPM is very similar to the WSM. The WPM is dimensionless analysis that can be used in single dimensional and multi-dimensional decision problems because its structure eliminates any units of measure.

2.3.3 Multi-Attribute Utility Theory (MAUT)

Multi-Attribute Utility Theory (MAUT) is evaluated for its applicability to benchmarking analysis. The MAUT is selected as a viable method for improving benchmarking analysis due to its relative ease for both formation and computation (Collins, 2006). According to MAUT, the overall evaluation *v(x)* of an object *x* is defined as weighted addition of its evaluation with respect to its relevant value dimensions (Schafer, 2001). The overall value function is defined as following equation:

$$v(x) = \sum_{i=1}^{n} w_i v_i(x) \tag{2.3}$$

$$\sum_{i=1}^{n} w_i = 1 \tag{2.4}$$

where, $v_i(x)$ is the evaluation of object on the *i-th* value dimension d_i and w_i the weight determining the impact of the *i-th* value dimension on the overall evaluation or called relative importance of a dimension and *n* is the number of different value dimensions.

For each value dimension d_i the evaluation $v_i(x)$ is defined as the evaluation of the relevant attributes (Schafer, 2001):

$$v_i(x) = \sum_{a \in A_i} w_{ai} v_{ai}(l(a)) \tag{2.5}$$

where, A_i is the set of all attributes relevant for d_i, $v_{ai}(l(a))$ is the evaluation of the actual level $l(a)$ of attribute a on d_i. w_{ai} is the weight determining the impact of the evaluation of attribute a on value dimension d_i. w_{ai} is also called relative importance of attribute a for d_i. For all d_i (*i=1,…,n*) holds $\sum_{a \in A_i} w_{ai} = 1$.

2.3.4 Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE)

The Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE) represents one of the most frequently used methods of multi-criteria decisions and have taken an important place among the existing outranking multiple criteria methods. The PROMETHEE method is based on mutual comparison of each alternative pair with respect to each of the selected criteria.

According to Brans (2005), the preference structure of PROMETHEE is based on pair-wise comparisons. The deviation between the evaluations of two alternatives on a particular criterion is considered. The larger the deviation, the larger the preference. The preferences between 0 and 1 is no objection to consider. The criterion the decision-maker function is:-

$$P_j(a,b) = F_j\left[d_j(a,b)\right] \qquad a,b \in A \tag{2.6}$$

where,

$$d_j(a,b) = g_j(a) - g_j(b) \tag{2.7}$$

for, $0 \leq P_j \leq 1$.

$P_j(a,b)$ is preference function and the degree of the preference of alternative a over b for criterion g_j. A multicriteria preference index $\pi(A_j, A_k)$ of A_j over A_k can be defined as:

$$\pi\left(A_j, A_k\right) = \sum_{i=1}^{m} w_i P_i(A_j, A_k) \tag{2.8}$$

The index between 0 and 1, and represent the global intensity of preference between the couples of alternatives.

2.3.5 Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) developed in the early 1970's by Thomas Saaty has gained wide popularity and acceptance throughout the world (Forman, 1993). The Analytic Hierarchy Process (AHP) is a theory of measurement through pair-wise comparison and relies on the judgments of experts to derive priority scales. AHP

concerns about the judgment that may be inconsistent and how to measure inconsistency and improve the judgments when possible to obtain consistency (Saaty, 2008). The AHP based on the well-defined mathematical structure of consistent matrices and their associated right-eigenvector's ability to generate true or approximate weight. The AHP methodology compares criteria or alternatives with respect to a criterion, in a natural, pair-wise mode.

According to Adamcsek (2008), AHP is based on three basic principles, which is decomposition, comparative judgments and hierarchic composition or synthesis of priorities. The decomposition principle was applied to structure a complex problem into a hierarchy of clusters. The principle of comparative judgments was applied to construct pair wise comparisons of all combinations of elements in a cluster with respect to the parent of the cluster. These pair wise comparisons are used to derive local priorities of the elements in a cluster with respect to their parent. The principle of hierarchic composition or synthesis was applied to multiply the local priorities of elements in a cluster by the global priority of the parent element, producing global priorities throughout the hierarchy and then adding the global priorities for the lowest level elements or alternatives.

The alternative choices on AHP that are ranking and prioritizing are compared and evaluated against stated criteria. The AHP is simple and elegant that has a unique and valid mathematical basis. Its application departs from the traditional decision analysis school where preferences are expressed using utilities whose values depend on one's aversion or proneness to risk. According to Thomas Saaty, the AHP is based on three principles of human behavior. Firstly, the decomposition of a complex problem to understand it. Secondly, the comparison of its parts to determine the degree or intensity of their interaction and influence on the whole. Lastly, synthesis to assemble the understanding and knowledge gathered when studying the parts and their interactions (Saaty, 2011).

A hierarchy is an element in a given level does not have to function as an attribute or criterion for all the elements in the level below. A hierarchy is *not* the traditional decision tree (Saaty, 1987). The AHP is a decision support tool which can be used to solve complex decision problems. The AHP uses a multi-level hierarchical structure of objectives, criteria, sub-criteria, and alternatives. The pertinent data are derived by using a set of pair wise comparisons. These comparisons are used to obtain the weights of importance of the decision criteria, and the relative performance measures of the alternatives in terms of each individual decision criterion. If the comparisons are not perfectly consistent, then it provides a mechanism for improving consistency (Triantaphyllou, 1995).

The AHP is a method that can be used to establish measures in both the physical and social domains. In using the AHP to model a problem, one needs a hierarchic structure to represent that problem, as well as pair wise comparisons to establish relations within the structure. In the discrete case these comparisons lead to dominance matrices. Then, the ratio scales are derived in the form of principal eigenvectors or eigenfunctions. In particular, special effort has been made to characterize these matrices. Because of the need for a variety of judgments, there has also been considerable work done to deal with the process of synthesizing group judgments (Saaty and Vargas, 2001).

The AHP is a powerful and flexible decision-making process to assist people set priorities and make the best decision when both qualitative and quantitative aspects of a decision need to be considered. By reducing complex decisions to a series of pair wise comparisons, then synthesizing the results, AHP not only helps decision-makers arrive at the best decision, but also provides a clear rationale for the decision. Designed to reflect the way people actually think, AHP continues to be the most highly regarded and widely used decision-making theory (Golec and Kahya, 2007).

2.3.6 Elimination and Choice Translating Reality (ELECTRE)

The Elimination and Choice Translating Reality (ELECTRE) is another type of MADM. The ELECTRE performs pair wise comparisons among the alternatives, in order to establish outranking relationships between them. The ELECTRE method was first developed by Bernard Roy (Charilas, 2009). The ELECTRE method has several unique features not found in other solution method because these are the concepts of outranking and indifferent and preference threshold (Buchanan, 1998).

The ELECTRE is the utilization of fuzzy concept in decision making process and one of the most widely used method to rank a set of alternatives versus a set of criteria to reflect the decision maker's preference. Relationship between alternatives and criteria are described using attributes referred to the aspect of alternatives that are relevant according to the established criteria. The ELECTRE is based upon the pseudocriteria by using proper thresholds. The ELECTRE method are different from other methodologies because it is not compensative that is very bad score in one objective function is not compensated by good scores in other objectives. If the difference between the values of an attribute of two alternatives is greater than a fixed veto threshold, decision maker will not choose an alternative if it is very bad compared to another one, even on a single criterion (Vahdani, 2010).

The ELECTRE method is not being presented as the best decision aid but it is one proven approach (Buchanan, 1998). The ELECTRE method and its derivatives such as ELECTRE I, ELECTRE II, ELECTRE III and ELECTRE IV have played a prominent role in the group of outranking methods. The main objective in ELECTRE is the proper utilization of the outranking relations that enable the utilization of incomplete value information. The ELECTRE I method is used to construct a partial prioritization and choose a set of promising actions. Then, ELECTRE II is used for ranking the actions. While, in ELECTRE III an outranking degree is established, representing an outranking creditability between two actions which makes this method more sophisticated and difficult to interpret (Hatami, 2011).

The ELECTRE method has two important concepts underscore the ELECTRE approach. That is thresholds and outranking. The indifferent threshold is specified by the decision maker. In order to develop the outranking relationship, there are two further definition are required that is concordance and discordance (Buchanan, 1998). The decision maker uses concordance and discordance indices to analyze outranking relations among different alternatives and to choose the best alternative using the crisp data (Wu, 2011).

2.4 Strengths and Weaknesses of MCDM

Every Multi-Criteria Decision Making (MCDM) method has its own strong points and weak points. The strengths and weaknesses method in MCDM such as Weighted Sum Model (WSM), Weighted Product Model (WPM), Multi-Attribute Utility Theory (MAUT), Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE), Analytic Hierarchy Process (AHP) and Elimination And Choice Translating Reality I (ELECTRE I) will be discuss in following Table 2.1.

Table 2.1 Strengths and Weaknesses of MCDM

Method	**Strengths**	**Weaknesses**
Weighted Sum Model (WSM)	• Strong in a single dimensional problems	• Difficulty emerges on multi-dimensional problems
Weighted Product Model (WPM)	• Can be used in single and multi dimensional problems. • Instead of actual values, it can use relative ones.	• No solution with equal weight of decision makers.
Multi-Attribute Utility Theory (MAUT)	• Easier to compare alternatives whose overall scores are expressed as single numbers.	• Maximization of utility may not be important to decision makers.
Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE)	• Precise and sophisticated modeling of decision maker's preferences.	• Relative position in the final rank between variants can change by adding or deleting another variant.
Elimination And Choice Translating Reality I (ELECTRE I)	• The degree of the alternatives with respect to different criteria can be evaluated on the basis of a common scale. • Precise comparisons between alternatives, allows decision makers evaluate each alternatives with respect to each sub-criteria.	• The roles played by the discordance and concordance have no clear corollary in common sense decision making.
Analytic Hierarchy Process (AHP)	• Hierarchical representation of the considered decision problem, which gives clear, formal structure of the situation. It very useful for complex problems. • Precise comparisons between criteria, which allows the decision makers to focus on each component. • Surveying pair-wise comparisons is easy to implement.	• Inconsistencies of the DM judgments based on the restriction of 1 to 9 scales. • Consistency Ratio CR is often higher than 0.1 and the improvement of its value is ambiguous.

Based on the table above, it shows that the most suitable method to apply in this study is AHP and ELECTRE I. AHP is choosen since it is very useful for a complex problems as selection of academic staff is a complex process involving several criteria and sub-criteria to select best candidate. ELECTRE I precise comparison between alternatives which allows the experts in selection academic staff to focus evaluate each candidate with respect to each sub-criteria separately.

2.5 Summary

This chapter discussed the literature on academic staff selection problem and important background for the study of application of MCDM in the selection of academic staff. It describes generally the method of AHP and ELECTRE I used in this study. In the last section, the method of MCDM were discussed the strengths and weaknesses of MCDM method.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter starts by introducing the research design and procedures which including the data collection for this study. A description of the Analytic Hierarchy Process (AHP) and Elimination and Choice Translating Reality I (ELECTRE I) is discussed in detail in the next section. Finally, the application of AHP and ELECTRE I as decision making aiding tools will be discussed.

3.2 Research Design and Procedure

This research is about decision making process in which our goal is to select the most appropriate academic staff in Faculty of Science, UTM. We implement the Analytic Hierarchy Process (AHP) and Elimination and Choice Translating Reality I (ELECTRE I) in selection of academic staff in this study.

3.2.1 Data Collection

Knowledge acquisition is the process of extracting, structuring and organizing knowledge from one source that is human experts. In this research, the knowledge that needs to capture from the experts is the criteria for the selection of academic staff in Faculty of Science, UTM. Other than that, this research will also capture the importance of each criterion for selection academic staff. Several techniques can be used in the knowledge acquisition. In this research, the interview with experts are the technique that is used in this research. Otherwise, to get useful information for academic staff selection, the analysis of existing documents and references from various sources will be used in this research.

In this research, the deputy registrar (Human Capital Management Division) from Registrars' Office, UTM and assistant registrar (Human Resource) from Faculty of Science, UTM who directly involved in the selection of academic staff as the experts that have been interviewed to obtain the useful information about criteria of selection of academic staff in Faculty of Science, UTM .

3.2.2 Information from experts

The qualitative information gathered from experts from the process of knowledge acquisition can be transform into quantitative information or data. The quantitative data transformed is then use to find the priorities of each of the criteria and sub-criteria, which need to ranking the most appropriate academic staff in this study.

In this study, the geometric mean is used to combine judgments of different individuals. The geometric mean is calculated to obtain the priorities for each of the criteria and sub-criteria based on judgment from experts. The data is obtained from two experts in this study, it is calculated by using the geometric mean from the two individual experts responses to obtain the consensus judgments in this study.

The geometric mean are calculated by using Microsoft Excel 2007 before transferring the processed data into Expert Choice 11.0 to obtain the criteria and sub-criteria priorities or weights. Let the judgment for relative importance of criteria 1 to criteria 2 is given $X_1, X_2, \dots, X_n$ by n experts respectively, the geometric mean are calculated by using formula

$$\text{Geometric mean} = \sqrt[\frac{1}{n}]{X_1 \text{ x } X_2 \text{ x} \dots \text{x } X_n}$$

For example, the two experts regard the relative importance of Academic over Extracurricular Activities as 6 and 3 respectively. Then relative importance of Academic will be $\sqrt[\frac{1}{2}]{6 \text{ x } 3} = 4.2426$, and this will be used as the judgment.

3.2.3 Selection Criteria

In this study, there are six main criteria identified to be included in the AHP and ELECTRE I model to select academic staff in Faculty of Science, UTM. Some criteria used by UTM academic staff selection committee can be grouped under one criterion. Some of the relevant criteria that are not mentioned in the UTM selection criteria are added in this decision making model. The criteria used can be easily changed or modified in the model depend on the requirement of the faculty in the process of selecting an appropriate academic staff. The criteria chosen in this study are the academic, general attitudes, interpersonal skill, experience, extracurricular activities, and referees report.

The criterion of academic is further expanded to include the sub-criteria of education background, research paper, and general knowledge. This sub-criterion make a significant impact in the area of higher education that will affect a substantial number of academic institutions.

Self-confidence, appearance, and age are categorized as the sub-criteria for general attitudes. The attitudes of individuals play the important role in human social behavior. Self-confidence is an attitude that allows individuals to be positive person and have realistic views of themselves and their situations.

The next criteria for evaluation of a candidate are interpersonal skill of each candidate. The sub-criteria of interpersonal skills in this evaluation are communication skill, teaching skill, and ability to communicate English. Interpersonal skill that we use every day to communicate and interact with other people is communication skill. All the sub-criteria of interpersonal skill have own importance that is required in the process of selection of academic staff.

Other than that, the main criteria to evaluated candidates are experience. The candidates that have good qualification and little experience may not be as efficient as a person that has more experiences. The sub-criteria for experiences include teaching experience, working field experience and working duration experience.

The criteria of extracurricular activities are broken down into the sub-criteria of awards, the position of candidates in activities and participation in activities they join. The candidates who have the extra-curricular activities can increase the sociability that is a crucial ability for personal development and important criteria for selection academic staff. Finally, the referees report is another criteria used to the selection of academic staff in this study.

3.2.4 Hierarchical Structure

Figure 3.1 shows the hierarchical structure for the academic staff selection constructed using the criteria and sub-criteria as discussed.

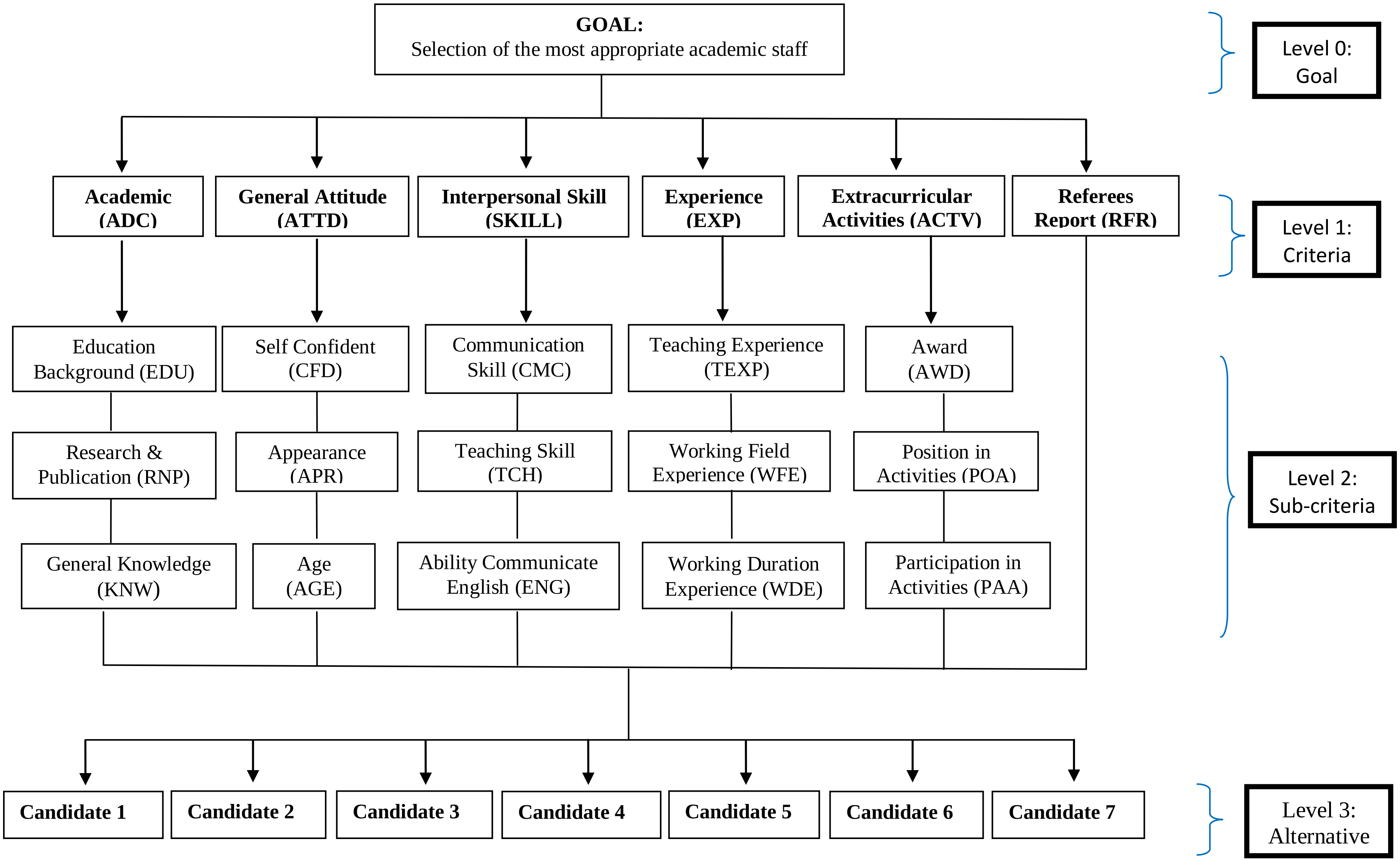


Figure 3.1 Hierarchical Structure for Selection of Academic Staf

3.3 Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is a multi-criteria decision making approach in which factors are arranged in a hierarchic structure. To make a decision in organized way to generate priorities, the decompose of decision shows as the following steps (Saaty, 2008).

1. Define the problem and determine the kind of knowledge sought.

2. Structure the decision hierarchy from the top with the goal of the decision, then the objectives from a broad perspective, through the intermediate levels (criteria on which subsequent elements depend) to the lowest level (which usually is a set of the alternatives).

3. Construct a set of pair wise comparison matrices. Each element in an upper level is used to compare the elements in the level immediately below with respect to it.

4. Use the priorities obtained from the comparisons to weigh the priorities in the level immediately below. Do this for every element. Then for each element in the level below add its weighed values and obtain its overall or global priority. Continue this process of weighing and adding until the final priorities of the alternatives in the bottom most level are obtain.

To construct a set of pair wise comparisons, we need a scale of numbers that indicates how many times more important or dominant one element is over another element with respect to the criterion, which they are compared. Table 3.1 show the fundamental scale of absolute numbers as followed.

Table 3.1 The Fundamental Scale of Absolute Numbers

Intensitive of important	**Definition**	**Explanation**
1	Equal Importance	Two activities contribute equally to the objective
3	Moderate importance	Experience and judgement slightly favour one activity over another
5	Strong importance	Experience and judgement strongly favour one activity over another
7	Very strong or demonstrated importance	An activity is favoured very strongly over another. Its dominance demonstrated in practice
9	Extreme importance	The evidence favouring one activity over another is of the highest possible order of affirmation
2,4,6,8	Intermediate values between the two adjacent judgments	When compromise is needed
Reciprocals of above	If activity i has one of the above non-zero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i	A reasonable assumption
1.1–1.9	If the activities are very close	May be difficult to assign the best value but when compare with other contrasting activities the size of the small numbers would not be too noticeable, yet they can still indicate the relative importance of the activities.

Assuming *n* criteria exist, the pair wise comparison *n x n* matrix A as following form:

$$A = [a_{ij}] = \begin{matrix} & C_1 & C_2 & \cdots & C_n \\ C_1 & 1 & a_{12} & \cdots & a_{1n} \\ C_2 & \frac{1}{a_{12}} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & 1 & \vdots \\ C_n & \frac{1}{a_{1n}} & \frac{1}{a_{2n}} & \ldots & 1 \end{matrix} \tag{3.1}$$

Matrix $A = (a_{ij})$ is of order n with the condition that $a_{ji} = {}^{1}/{a_{ij}}$, for $i \neq j$, and $a_{ii} = 1$ for all i. Let $C_1, C_2, \ldots, C_n$ denote the set of criteria, while the a_{ij} represent a judgement on a pair of criteria C_i, C_j. The results of pair wise comparison of the n criteria are put at the upper triangle of pair wise comparison matrix A. The lower triangle shows the value relative position for the reciprocal values of the upper triangle.

The matrix are consistent if they are transitive, that is $a_{ik} = a_{ij}\, a_{jk}$ for all *i, j,* and *k*. Then, find the vector ω of order n such that $A\omega = \lambda\omega$. For such a matrix, ω is said to be an eigenvector of order *n* and λ is an eigenvalue. For a consistent matrix, $\lambda = n$.

For matrices involving human judgment, the condition $a_{ik} = a_{ij}\, a_{jk}$ does not hold as human judgments are inconsistent to a greater or lesser degree. In such a case the ω vector satisfies the equation $A\omega = \lambda_{max}\, \omega$ and $\lambda_{max} \geq n$. The difference, if any, between λ_{max} and *n* is an indication of the inconsistency of the judgments. If $\lambda_{max} = n$ then the judgments have turned out to be consistent.

The Consistency Index is to measure the inconsistency present in matrix. Consistency Index can be calculated by using the formula:

$$C.I = \frac{\lambda_{max} - n}{n-1} \qquad (3.2)$$

The Consistency Ratio is calculated by dividing the Consistency Index for the set of judgments by the Index for the corresponding random matrix. The formula for Consistency Ratio as below:

$$C.R = \frac{C.I}{R.I} \qquad (3.3)$$

If that ratio exceeds 0.1 the set of judgments may be too inconsistent to be reliable. But for ratio does not exceed 0.1, the *C.R* is acceptable. While, if ratio is 0 means that the judgment are perfectly consistent. Otherwise, we need to revise the matrix. The random index (average consistency indices), *R.I* are showed in following table.

Table 3.2 Random index for various matrices size

Size matrix, n	1	2	3	4	5	6	7	8	9	10
Random consistency	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

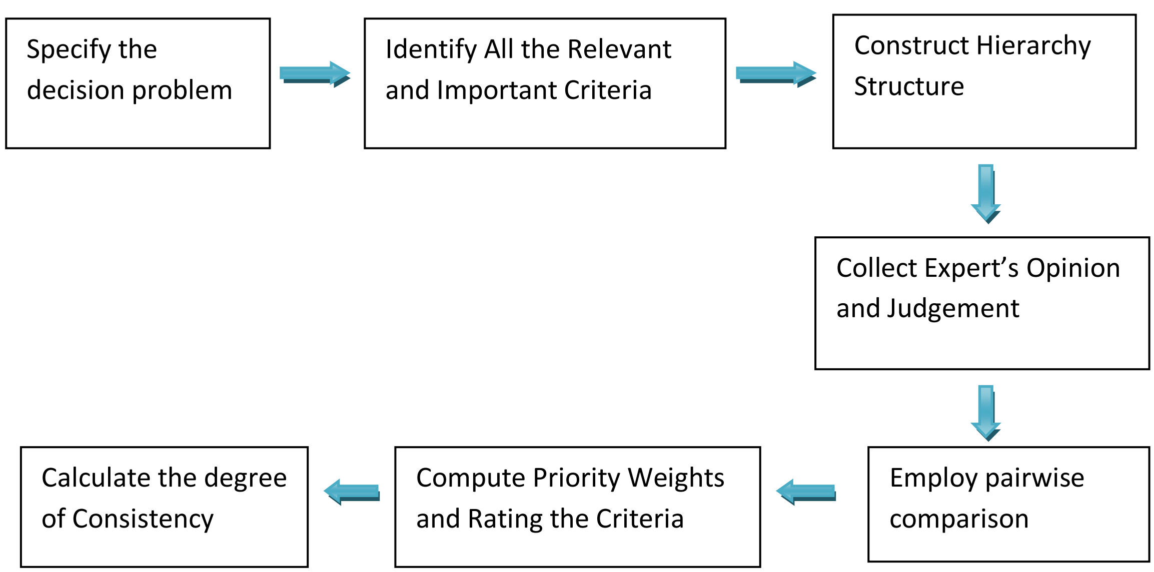


Figure 3.2 The general AHP steps used in this research.

3.4 Elimination and choice translating reality (ELECTRE)

The elimination and choice translating reality (ELECTRE) method as outranking relation theory was used to analyze the data of a decision matrix to rank a set of alternatives. The outranking relations are determined by concordance and discordance. ELECTRE proceeds to a pair-wise comparison of alternatives in each single criterion in order to determine partial binary relations denoting the strength of preference of one alternative over the other. There are several derivatives of ELECTRE method but the ELECTRE I approach will be used to obtain the ranking of alternatives in this research.

Suppose that $A_1, A_2, \dots, A_m$ are m possible alternatives among which decision makers have to choose, $C_1, C_2, \dots, C_n$ are the criteria that use to described the alternatives characters, x_{ij} is the rating of alternatives A_i with respect to criterion C_j. Let W_n be the weight for the importance of C_n. The computational flow process of ELECTRE I method is stated in the following paragraphs (Vahdani et al, 2010):-

Step 1. Convert the decision matrix and weighted matrix

Convert the decision matrix into normalized matrix, $R_{ij} = [r_{ij}]$ calculated by using Equation (3.4):

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}, \qquad i = 1,2, \dots, n. \ j = 1,2, \dots, m. \tag{3.4}$$

The weight normalized matrix calculated by Equation (3.5):

$$V_{ij} = R \times W = \begin{vmatrix} r_{11}.w_1 & r_{21}.w_2 & \cdots & r_{1n}.w_n \\ r_{21}.w_1 & r_{22}.w_2 & \cdots & r_{2n}.w_n \\ \vdots & \vdots & \ddots & \vdots \\ r_{m1}.w_1 & r_{m2}.w_2 & \cdots & r_{mn}.w_n \end{vmatrix} \tag{3.5}$$

The weights of the attributes are expressed by these constants, $0 \leq w_1, w_2, \ldots, w_n \leq 1$. The correlation coefficients of normalized interval numbers within the [0, 1].

Step 2. Specify concordance and discordance sets

Let A = $\{a, b, c, \ldots\}$ denote a finite set of alternatives. The concordance set is applied to described the dominance query if following condition satisfied:

$$C_{ab} = \{j | x_{aj} \geq x_{bj}\} \tag{3.6}$$

The complementary of C_{ab}, named the discordance set by Equation (3.7)

$$D_{ab} = \{j | x_{aj} < x_{bj}\} = J - C_{ab} \tag{3.7}$$

Step 3. Calculation of the concordance and discordance matrix

The concordance index, $c(a, b)$indicates relative dominance of alternative 'a' over alternative 'b', based on the relative importance weightings of the relevant decision attributes. The concordance index, $c(a, b)$between A_a and A_b obtained using Equation (3.8)

$$c(a, b) = \sum_{j \in C_{ab}} w_j \tag{3.8}$$

The concordance matrix is in the following manner:

$$C = \begin{vmatrix} - & c(1,2) & \cdots & c(1,m) \\ c(2,1) & - & \cdots & c(2,m) \\ \vdots & \vdots & \ddots & \vdots \\ c(m,1) & c(m,2) & \cdots & - \end{vmatrix} \tag{3.9}$$

The discordance index, $d(a,b)$ measures the degree to which alternative 'a' is worse than 'b'. The discordance index of $d(a,b)$ defined as follow Equation (3.10):

$$d(a,b) = \frac{\max_{j \in D_{ab}} |v_{aj} - v_{bj}|}{\max_{j \in J, m, n \in I} |v_{mj} - v_{nj}|} \quad (3.10)$$

where, m and n is used is used to calculate the weighted normalized value among all scheme target attributes. Using discordance index sets discordance matrix is defined as

$$D = \begin{vmatrix} - & d(1,2) & \cdots & d(1,m) \\ d(2,1) & - & \cdots & d(2,m) \\ \vdots & \vdots & \ddots & \vdots \\ d(m,1) & d(m,2) & \cdots & - \end{vmatrix} \quad (3.11)$$

Step 4. Determine the concordance index matrix

The concordance index matrix can be written as follows Equation (3.12):

$$\bar{c} = \sum_{a=1}^{m} \sum_{b}^{m} \frac{c(a,b)}{m(m-1)} \quad (3.12)$$

where, $\bar{c}$ is the critical value.

Then, we construct the Boolean matrix, E (effective concordance matrix) given by the following Equation (3.13)

$$\begin{cases} e(a,b) = 1 & if \quad c(a,b) \geq \bar{c} \\ e(a,b) = 0 & if \quad c(a,b) < \bar{c} \end{cases} \quad (3.13)$$

Step 5. Determine the discordance index matrix

On contrary, the discordance index matrix measured by Equation(3.14)

$$\bar{d} = \sum_{a=1}^{m} \sum_{b}^{m} \frac{d\,(a,b)}{m\,(m-1)} \tag{3.14}$$

Then, we construct the Boolean matrix, F (effective discordance matrix) given by following Equation (3.15)

$$\begin{cases} f(a,b) = 1 & if \quad d(a,b) \leq \bar{d} \\ f(a,b) = 0 & if \quad d(a,b) > \bar{d} \end{cases} \tag{3.15}$$

Step 6. Calculate the outranking matrix

Common elements ($h_{k,l}$) construct outranking matrix (*H)* for making decision from matrix *E* and matrix *F* with the following formula:

$$h_{k,l} = e_{k,l}.f_{k,l} \tag{3.16}$$

Outranking matrix (*H*) indicates the order of relative superiority of alternatives. This means that if $h_{k,l} = 1, A_k$ is superior to A_l in terms of both concordance index and discordance index. However, A_k might still be dominated by other alternatives. We can eliminate those column of (*H)* which at least possess a unit element (1) from matrix (*H*) because those columns are dominated by other rows.

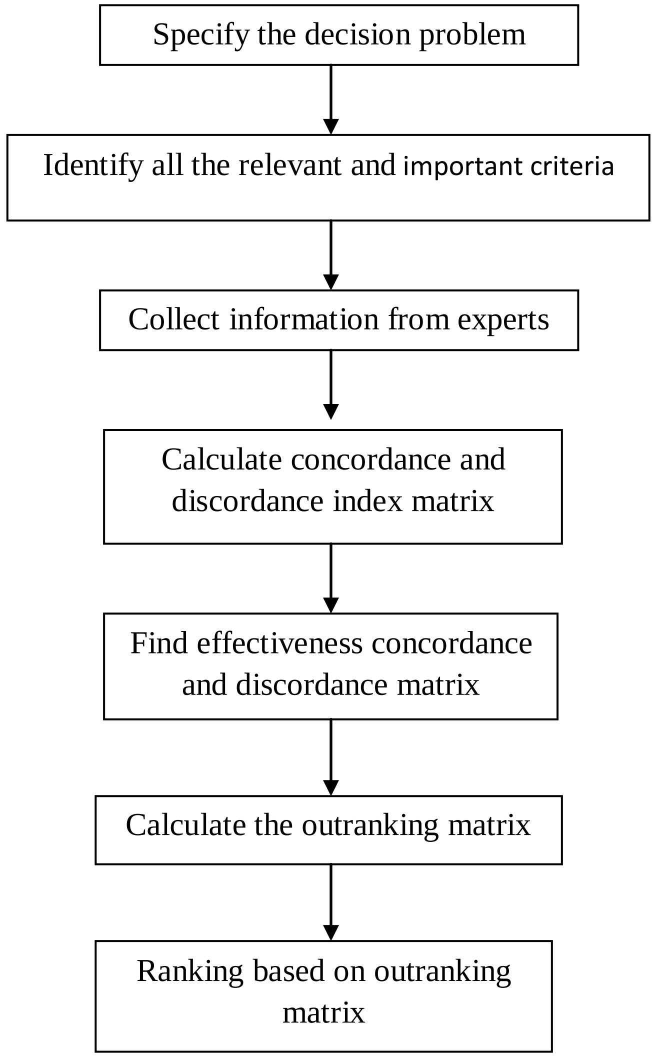


Figure 3.3 The general ELECTRE I steps used in this research.

3.5 Summary

Knowledge acquisition is done by interviewing experts in this study. A simulation model of AHP and ELECTRE I aided decision making tool was developed in this study. This chapters also details the steps of AHP and ELECTRE I method that used in this study. The selection criteria and sub-criteria for academic staff constructed in the hierarchy structure.

CHAPTER 4

THE AHP AND ELECTRE I ACADEMIC STAFF SELECTION MODEL

4.1 Introduction

This chapter discusses the development of the theoretical model for the selection of academic staff in Faculty of Science, UTM by using MCDM. The types of MCDM used in this study is AHP and ELECTRE I. The process involves in the development model are discussed in detail in this chapter. The software of Expert Choice 11.0 being used to synthesize the AHP method and synthesizing priorities for the academic staff selection criteria and sub-criteria used in this study. While, Microsoft Excel 2007 software is used in the calculation of ELECTRE I method applying in this study.

4.2 The AHP Model for Academic Staff Selection

In this section, the application of AHP model will be discussed details. This application will start by differentiating the relative importance for each of the criteria during the process of interviewing experts by using pair-wise comparison table for each criteria and sub-criteria used in this study. The judgments of experts use scale 1 to 9 in Table 3.1 as suggested by Saaty (2008).

There are different pair-wise comparison table at each level of hierarchy and different pair-wise comparison table for each criteria and sub-criteria. Table 4.1 list all the possible pair-wise comparison for level 1 containing six criteria. There are another five separate table listing the three sub-criteria for criteria Academic, General Attitudes, Interpersonal Skill, Experiences, and Extracurricular Activities respectively.

The pair-wise comparison for each of the criteria and sub-criteria are formed by using processed data obtained from the calculation of the geometric mean as discussed in Chapter 3. The pair-wise comparison of each criteria and sub-criteria is reduced into a square matrix as shown in Table 4.1, Table 4.2, Table 4.3, Table 4.4, Table 4.5 and Table 4.6.

Table 4.1 Pair-wise comparison matrix for the six selection criteria

Criteria	ADC	ATTD	SKILL	EXP	ACTV	RFR
ADC	1.0000	6.0891	4.2912	5.7521	6.3112	8.3344
ATTD	0.1642	1.0000	2.1831	4.8011	3.7442	6.5030
SKILL	0.2331	0.4583	1.0000	1.5421	2.0531	3.0910
EXP	0.1741	0.2083	0.6492	1.0000	4.8022	3.2523
ACTV	0.1582	0.2674	0.4872	0.2083	1.0000	2.4831
RFR	0.1202	0.1544	0.3241	0.3084	0.4032	1.0000

Table 4.2 Pair-wise comparison matrix for the Academic, ADC

Sub-criteria of ADC	EDU	RNP	KNW
EDU	1.0000	7.6324	6.1334
RNP	0.1310	1.0000	1.2821
KNW	0.1630	0.7800	1.0000

Table 4.3 Pair-wise comparison matrix for the General Attitudes, ATTD

Sub-criteria of ATTD	CFD	APR	AGE
CFD	1.0000	4.2892	8.9312
APR	0.2331	1.0000	3.1411
AGE	0.1122	0.3182	1.0000

Table 4.4 Pair-wise comparison matrix for the Interpersonal Skill, SKILL

Sub-criteria of SKILL	**CMC**	**TCH**	**ENG**
CMC	1.0000	1.0000	2.5732
TCH	1.000	1.0000	4.5511
ENG	0.3891	0.2202	1.0000

Table 4.5 Pair-wise comparison matrix for the Experiences, EXP

Sub-criteria of EXP	**TEXP**	**WFE**	**WDE**
TEXP	1.0000	3.8443	4.0611
WFE	0.2600	1.0000	2.3321
WDE	0.2461	0.4291	1.0000

Table 4.6 Pair-wise comparison matrix for the Extracurricular Activities, ACTV

Sub-criteria of ACTV	**AWD**	**POA**	**PAA**
AWD	1.0000	1.1880	1.0842
POA	0.8422	1.0000	1.1441
PAA	0.9231	0.8741	1.0000

4.2.1 Calculation of Priority for Element

The following steps used to calculate the priority of each criteria and sub-criteria by referring to the pair-wise comparison matrix as stated in previous section. By using the matrix of the sub-criterion of Academic (ADC) in Table 4.2 as an example, the weights or priorities, Eigenvalue (λ_{max}), Consistency Index (*C.I*), and Consistency Ratio (*C.R*) of criteria or sub-criteria can be calculated as shown below.

Step 1: Sum the values in each column of the pair-wise comparison matrix.

Table 4.7 Pair-wise comparison matrix for the Academic, ADC

Sub-criteria of ADC	EDU	RNP	KNW
EDU	1.0000	7.6324	6.1334
RNP	0.1310	1.0000	1.2821
KNW	0.1630	0.7800	1.0000
TOTAL	1.2940	9.4124	8.4155

Step 2: Develop the normalized pair-wise comparison matrix, A. Divide each element in the pair-wise comparison matrix by its column total. The resulting matrix will gives normalized pair-wise comparison matrix, A.

$$A = \begin{bmatrix} a'_{11} & a'_{12} & \cdots & a'_{1n} \\ a'_{21} & a'_{22} & & a'_{2n} \\ \vdots & & \ddots & \vdots \\ a'_{n1} & a'_{n2} & \cdots & a'_{mn} \end{bmatrix}$$

and $a'_{ij} = \frac{a_{ij}}{\sum_{i=1}^{n} a_{ij}}$ for i, j = 1,2,...n.

The normalized pair-wise comparison matrix, A as below:

$$A = \begin{bmatrix} 0.7728 & 0.8109 & 0.7288 \\ 0.1012 & 0.1062 & 0.1523 \\ 0.1260 & 0.0829 & 0.1188 \end{bmatrix}$$

Step 3: Compute the average of the elements in each row of the normalized pair-wise comparison matrix. These will provide the relative priorities, W of elements being compared.

$$W = \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{pmatrix} \quad \text{and} \quad w_i = \frac{\sum_{i=1}^{n} a'_{ij}}{n} \quad \text{for i, j = 1,2,…n.}$$

$$\text{Relative priority, } W = \begin{pmatrix} w_1 \\ w_2 \\ w_3 \end{pmatrix} = \begin{pmatrix} 0.7708 \\ 0.1199 \\ 0.1092 \end{pmatrix}$$

The above discussion shows that the relative priorities for each sub-criteria of Academic (ADC) are 0.7708 for Education Background (EDU), 0.1199 for Research and Publication (RNP) and 0.1092 for General Knowledge (KNW) respectively.

Next, we need to check the consistency of the criteria and sub-criteria pair-wise comparison matrix. By using AHP, we can measure the degree of consistency and if unacceptable, we can revise pair-wise comparison. Let us test the consistency of criteria of Academic (ADC). The procedure for computing the consistency of a pair-wise comparison matrix is as follows:

Firstly, multiply pair-wise comparison matrix, A by relative priorities, W.

$$A.W = \begin{pmatrix} 0.7728 & 0.8109 & 0.7288 \\ 0.1012 & 0.1062 & 0.1523 \\ 0.1260 & 0.0829 & 0.1188 \end{pmatrix} . \begin{pmatrix} 0.7708 \\ 0.1199 \\ 0.1092 \end{pmatrix} = \begin{pmatrix} 2.3557 \\ 0.3609 \\ 0.3284 \end{pmatrix}$$

$$\begin{pmatrix} W_1' \\ W_2' \\ W_3' \end{pmatrix} = \begin{pmatrix} 2.3557 \\ 0.3609 \\ 0.3284 \end{pmatrix}$$

Then, the calculation of λ_{max}, which is average of $(\frac{Aw}{W})$ are as follow:

$$\lambda_{max} = \frac{1}{n}\left(\frac{w_1'}{w_1} + \frac{w_2'}{w_2} + \frac{w_3'}{w_3}\right)$$

$$= \frac{1}{3}\left(\frac{2.3557}{0.7708} + \frac{0.3609}{0.1199} + \frac{0.3284}{0.1092}\right)$$

$$= 3.0245$$

Since $n = 3$, the Consistency Index (*C.I*) can be calculated as below:

$$\text{Consistency Index,} \qquad C.I = \frac{\lambda_{max} - n}{n - 1}$$

$$= \frac{3.0245 - 3}{3 - 1}$$

$$= 0.0123$$

Finally, compute the Consistency Ratio *(C.R)* by comparing the Consistency Index (*C.I*) with Random Index (R.I) in Table 3.2.

$$\text{Consistency Ratio,} \qquad C.R = \frac{C.I}{R.I}$$

$$= \frac{0.0123}{0.58}$$

$$= 0.0211$$

By referring to the random consistency index in Table 3.2, the value of *R.I* depends on the number of items to compare, *n.* Since the value of *C.R* is less than 0.1, the judgment is acceptable. If the degrees of consistency are unacceptable, we can revise the pair-wise comparison matrix.

Similar calculation can be done to other matrices formed to obtain the priorities or weights for each of the criteria and sub-criteria. Besides using manual calculation, the value of consistency ratio can be obtain by using Expert Choice 11.0.

4.2.2 Estimation of Priority for Element Using Expert Choice 11.0

The pair-wise comparison that obtained through the calculation of geometric mean by using Microsoft Excel 2007 are transferred to the data grid in Expert Choice 11.0 to get the priorities of each of the criteria and sub-criteria. By using Expert Choice 11.0, the relative weights or priorities of each criteria and sub-criteria that obtained from expert can synthesize. The Figure 4.1 to Figure 4.6 show the screen shots captured from the Expert Choice 11.0 detailing the priorities of each criteria and sub-criteria in this study.

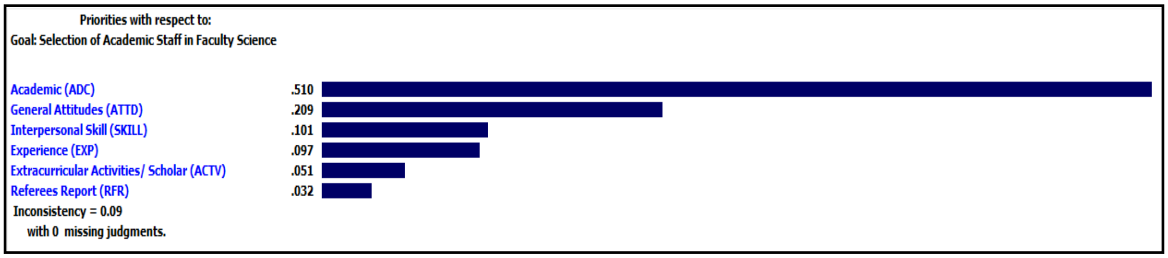


Figure 4.1 The Priorities of Six Criteria

From the Figure 4.1, it shows that the priority synthesized for the criteria of Academic (ADC), General Attitudes (ATTD), Interpersonal Skill (SKILL), Experience (EXP), Extracurricular Activities (ACTV) and Referees Report (RFR) are 0.510, 0.209, 0.101, 0.097, 0.051 and 0.032 respectively with consistency ratio, CR 0.09. Academic (ADC) has shown the highest priority, while Referees Report (RFR) has shown the lowest priority in the selection process. The result shows that Academic is the most important requirement to be fulfilled by a candidate in order to be selected as the academic staff.

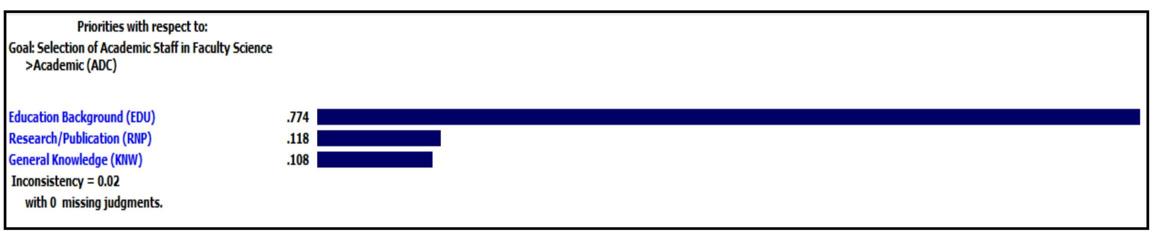


Figure 4.2 The Priorities for the sub-criteria of Academic, ADC

The relative priorities for the sub-criteria Academic (ADC) are shown in Figure 4.2. For the sub-criteria of Academic (ADC), Education Background (EDU) has the highest priority, 0.774, followed by Research and Publication (RNP), 0.118 and General Knowledge (KNW), 0.108 with consistency ratio, CR 0.02. It shows that the education background of candidate is highly important compared to other sub-criteria under criteria of Academic.

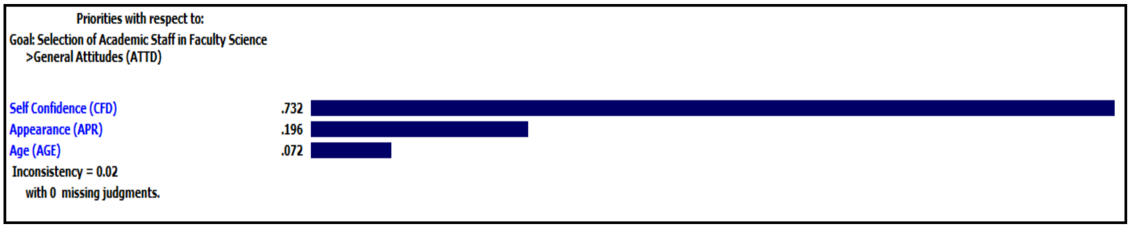


Figure 4.3 The Priorities for the sub-criteria of General Attitudes, ATTD

For the sub-criteria of General Attitudes (ATTD), Self Confidence (CFD) has scored the highest priority of 0.732 compared to Appearance (APR), 0.196 and Age (AGE), 0.072 with the consistency ratio, CR 0.02. The relative priorities for the sub-criteria of ATTD are show in Figure 4.3. Under criteria of General Attitude, the self confidence is the most important compared to other sub-criteria whereas the age of the candidate is not important comparatively in the selection of academic staff.

Figure 4.4 The Priorities for the sub-criteria of Interpersonal Skill, SKILL

The relative priorities for the sub-criteria Interpersonal Skill (SKILL) are show in Figure 4.4. For the sub-criteria of Interpersonal Skill (SKILL), Teaching Skill (TCH) has shown the highest priority of 0.478, followed by Communication Skill (CMC), 0.395 and Ability To Communicate English (ENG), 0.127 with consistency ratio, CR 0.03.

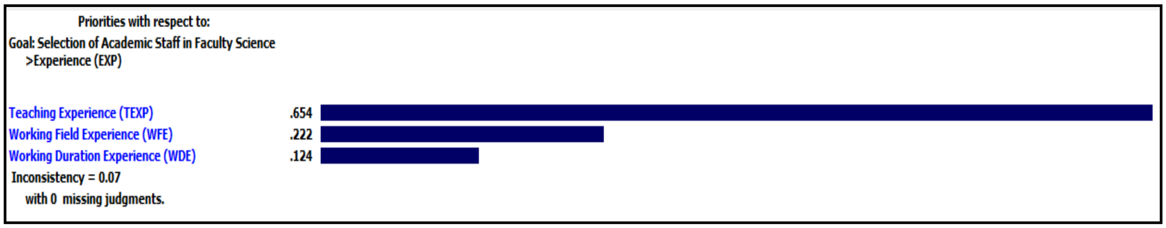


Figure 4.5 The Priorities for the sub-criteria of Experiences, EXP

For the sub-criteria of Experiences (EXP), Teaching Experience (TEXP) has highest priority of 0.654, followed by Working Field Experience (WFE), 0.222 and Working Duration Experience (WDE), 0.124 with consistency ratio, CR 0.07. The relative priorities for sub-criteria Experiences (EXP) are show in Figure 4.5. Teaching experience is highly important element compared to working duration experience element in selection of academic staff.

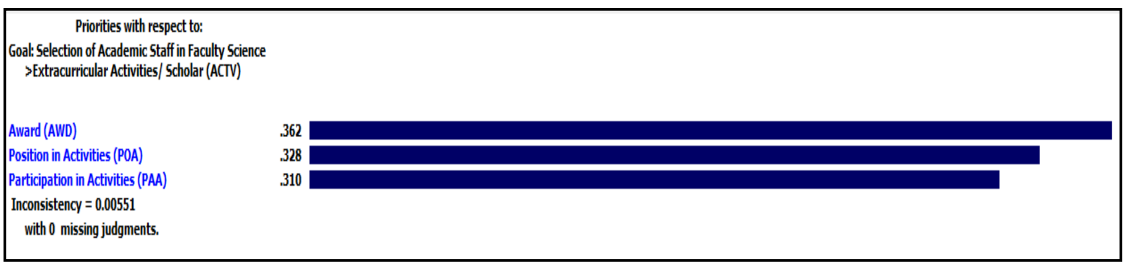


Figure 4.6 The Priorities for the sub-criteria of Extracurricular Activities, ACTV

The relative priorities for the sub-criteria Extracurricular Activities (ACTV) are shown in Figure 4.6. For the sub-criteria of Extracurricular Activities (ACTV), Award (AWD) has shown the highest priority of 0.362, followed by Position in Activities (POA), 0.328 and Participation in Activities (PAA), 0.310, with consistency ratio, CR 0.00551. Award is the most important key factor under the criteria of Extracurricular Activities while participation of candidate in activities is least important in selection of academic staff.

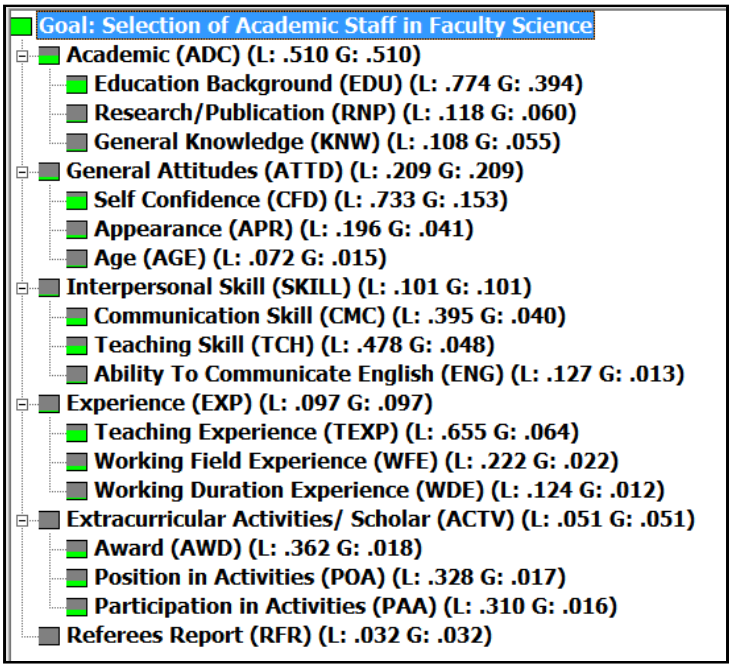


Figure 4.7 The local and global priorities of criteria and sub-criteria for selection academic staff by using Expert Choice 11.0

Figure 4.7 shows the local and global priorities synthesized by using Expert Choice 11.0 for every selection criteria and sub-criteria used in this academic staff selection model. In this study, the parents nodes are the selection criteria and the child nodes are the sub-criteria under each of the selection criteria. The local priority represents the percentage of the parents node's priority that is inherited by the child and add up to one. Whereas the priority of each node relative to the goal is called global priorities and the priorities of the objectives under the goal add up to 1.

4.2.3 Simulated Profile of Candidate

In this study, the simulated profiles of seven candidates after interview sessions with experts are generated. These simulated profiles are fed into the AHP model in this study. It is of the assumption that the profiles simulated have been transformed from the qualitative information to the quantitative data.

Table 4.8 to Table 4.23 show the pair-wise comparison of the seven candidate profiles generated. By referring to the first row in Table 4.8, it can be seen that for the EDU sub-criteria of ADC, Candidate 1 is 0.792 times more preferable than Candidate 2, 1.063 times more preferable than Candidate 3, 0.665 times more preferable than Candidate 4, 0.924 times more preferable than Candidate 5, 1.132 times more preferable than Candidate 6, and 1.022 times more preferable than Candidate 7. Candidate 1 is 1.022 times more preferable than Candidate 7 also means that Candidate 7 is 0.978 times more preferable than Candidate 1. This is because the reciprocal of 1.022 is 1/1.022 = 0.978. The similar pair-wise comparison for each of seven candidates done for EDU, RNP, KNW,CFD, APR, AGE, CMC, TCH, ENG, TEXP, WFE, WDE, AWD, POA, PAA, and RFR are shown in Appendix.

From the pair-wise comparison matrices formed, although the relative strong points of each candidates for each criteria and sub-criteria can be seen, but it is rather hard to identify the best candidate to be selected by looking at the separate pair-wise comparison matrices. Therefore, the quantitative data in the matrices need to be transferred to the data grid so that the ranking and analysis of the ranking results can be done using Expert Choice 11.0. The ranking of seven candidates in selection of academic staff in this study are done in the next chapter.

4.3 The ELECTRE I Model for Academic Staff Selection

In this section, the application of ELECTRE I model in the selection of academic staff discussed details. In this study, this application of ELECTRE I will starts by evaluating each alternative with respect to each sub-criteria. Experts evaluate the candidates with respect to the sub-criteria. The expert’s linguistic preferences converted into scale of numbers as shown in Table 3.1. All the value assigned to each of candidate with respect to each sub-criterion will form a decision matrix as shown in Table 4.24.

The ELECTRE I method is one method in MADM based on the concept of ranking through pair-wise comparison between alternatives on the appropriate criteria. This method is concerned with concordance, discordance, and outranking relationship. The decision makers use concordance and discordance indices to analyze outranking relations among different alternatives and to choose the best candidate using simulated data (Wu and Chen, 2011). In this ELECTRE I method, the AHP is applied to determine the relative weight for each sub-criteria by using Expert Choice. The score in decision matrix describes the performance of candidates against criterion. The relative weight for each sub-criteria are shown in Table 4.25.

Table 4.24 Decision matrix of candidates with respect to sub-criteria.

	EDU	RNP	KNW	CFD	APR	AGE	CMC	TCH	ENG	TEXP	WFE	WDE	AWD	POA	PAA	RFR
C1	3.340	4.360	5.290	4.700	8.210	5.980	3.570	2.130	2.670	3.230	5.400	4.330	5.110	5.920	4.960	2.650
C2	3.920	5.130	4.030	4.300	5.310	4.500	1.870	4.520	1.640	3.140	4.100	7.040	4.100	2.200	2.560	1.540
C3	6.470	3.280	5.900	4.800	4.950	8.360	7.430	5.700	3.100	5.780	2.300	5.100	3.200	4.500	3.120	4.130
C4	4.870	1.760	3.900	3.700	3.210	3.700	4.590	2.610	4.380	1.890	3.400	2.580	1.800	3.100	2.260	3.950
C5	2.250	2.890	3.100	2.900	1.870	2.700	5.240	1.290	4.210	2.530	1.500	1.650	7.400	3.500	3.190	2.320
C6	5.690	5.530	1.890	5.260	4.400	2.960	5.700	8.220	5.620	4.660	6.200	3.220	1.130	5.200	5.320	4.530
C7	7.110	6.570	6.230	4.500	2.940	7.310	4.320	5.870	4.500	3.580	7.000	4.310	7.600	5.400	5.700	5.110

Table 4.25 Relative weight for each sub-criteria.

	EDU	RNP	KNW	CFD	APR	AGE	CMC	TCH	ENG	TEXP	WFE	WDE	AWD	POA	PAA	RFR
Relative Weight, *W*	0.394	0.060	0.055	0.153	0.041	0.015	0.040	0.048	0.013	0.064	0.022	0.012	0.018	0.017	0.016	0.032

After forming the decision matrix, the normalization is applied. According to the normalization method, the normalized matrix can be determined by using Equation (3.4).

R =

0.249	0.367	0.437	0.407	0.645	0.414	0.273	0.164	0.257	0.326	0.437	0.376	0.392	0.504	0.459	0.273
0.292	0.432	0.333	0.372	0.417	0.311	0.143	0.349	0.158	0.317	0.332	0.611	0.314	0.187	0.237	0.159
0.482	0.276	0.488	0.415	0.389	0.578	0.568	0.440	0.298	0.583	0.186	0.443	0.245	0.383	0.288	0.426
0.363	0.148	0.323	0.320	0.252	0.256	0.351	0.201	0.421	0.191	0.275	0.224	0.138	0.264	0.209	0.407
0.168	0.243	0.256	0.251	0.147	0.187	0.401	0.100	0.405	0.255	0.121	0.143	0.567	0.298	0.295	0.239
0.424	0.465	0.156	0.455	0.346	0.205	0.436	0.634	0.540	0.470	0.502	0.280	0.087	0.442	0.492	0.467
0.530	0.553	0.515	0.389	0.231	0.506	0.330	0.453	0.433	0.361	0.567	0.374	0.583	0.459	0.527	0.527

The weighted normalized decision matrix calculated by multiplying the values of normalized matrix with the relative weight in Table 4.25. The weighted normalized decision matrix shown as follow:

V=

0.098	0.022	0.024	0.062	0.026	0.006	0.011	0.008	0.003	0.021	0.010	0.005	0.007	0.009	0.007	0.009
0.115	0.026	0.018	0.057	0.017	0.005	0.006	0.017	0.002	0.020	0.007	0.007	0.006	0.003	0.004	0.005
0.190	0.017	0.027	0.064	0.016	0.009	0.023	0.021	0.004	0.037	0.004	0.005	0.004	0.007	0.005	0.014
0.143	0.009	0.018	0.049	0.010	0.004	0.014	0.010	0.005	0.012	0.006	0.003	0.002	0.004	0.003	0.013
0.066	0.015	0.014	0.038	0.006	0.003	0.016	0.005	0.005	0.016	0.003	0.002	0.010	0.005	0.005	0.008
0.167	0.028	0.009	0.070	0.014	0.003	0.017	0.030	0.007	0.030	0.011	0.003	0.002	0.008	0.008	0.015
0.209	0.033	0.028	0.060	0.009	0.008	0.013	0.022	0.006	0.023	0.012	0.004	0.010	0.008	0.008	0.017

Based on Equation (3.6), the concordance sets for each pair of alternatives can be ascertained as follows:

C12 =	{3,4,5,6,7,9,10,11,13,14,15,16}	C41 =	{1,7,8,9,16}
C13 =	{2,5,11,13,14,15}	C42 =	{1,7,9,14,16}
C14 =	{2,3,4,5,6,10,11,12,13,14,15}	C43 =	{9,11}
C15 =	{1,2,3,4,5,6,8,10,11,12,14,15,16}	C45 =	{1,3,4,5,6,8,9,11,12,16}
C16 =	{3,5,6,12,13,14,15}	C46 =	{1,3,6,13}
C17 =	{4,5,12,14}	C47 =	{5,7}
C21 =	{1,2,8,12}	C51 =	{7,9,13}
C23 =	{2,5,11,12,13}	C52 =	{7,9,13,14,15,16}
C24 =	{2,3,4,5,6,8,10,11,12,13,15}	C53 =	{9,13,15}
C25 =	{1,2,3,4,5,6,8,10,11,12}	C54 =	{2,7,10,13,14,15}
C26 =	{3,5,6,12,13}	C56 =	{3,13}
C27 =	{5,12}	C57 =	{7}
C31 =	{1,3,4,6,7,8,9,10,12,16}	C61 =	{1,2,4,7,8,9,10,11,16}
C32 =	{1,3,4,6,7,8,9,10,14,15,16}	C62 =	{1,2,4,7,8,9,10,11,14,15,16}
C34 =	{1,2,3,4,5,6,7,8,10,12,13,14,15,16}	C63 =	{2,4,8,9,11,14,15,16}
C35 =	{1,2,3,4,5,6,7,8,10,11,12,14,16}	C64 =	{2,4,5,7,8,9,10,11,12,14,15,16}
C36 =	{1,3,5,6,7,10,12,13}	C65 =	{1,2,4,5,6,7,8,9,10,11,12,14,15,16}
C37 =	{4,5,6,7,10,12}	C67 =	{4,5,7,8,9,10}
C71 =	{1,2,3,6,7,8,9,10,11,13,15,16}		
C72 =	{1,2,3,4,6,7,8,9,10,11,13,14,15,16}		
C73 =	{1,2,3,8,9,11,13,14,15,16}		
C74 =	{1,2,3,4,6,8,9,10,11,12,13,14,15,16}		
C75 =	{1,2,3,4,5,6,8,9,10,11,12,13,14,15,16}		
C76 =	{1,2,3,6,11,12,13,14,15,16}		
C71 =	{1,2,3,6,7,8,9,10,11,13,15,16}		

The contrary of concordance set, we obtain the discordance sets using Equation (3.7) as follows:

D12 =	{1,2,8,12}	D41 =	{2,3,4,5,6,10,11,12,13,14,15}
D13 =	{1,3,4,6,7,8,9,10,12,16}	D42 =	{2,3,4,5,6,8,10,11,12,13,15}
D14 =	{1,7,8,9,16}	D43 =	{1,2,3,4,5,6,7,8,10,12,13,14,15,16}
D15 =	{7,9,13}	D45 =	{2,7,10,13,14,15}
D16 =	{1,2,4,7,8,9,10,11,16}	D46 =	{2,4,5,7,8,9,10,11,12,14,15,16}
D17 =	{1,2,3,6,7,8,9,10,11,13,15,16}	D47 =	{1,2,3,4,6,8,9,10,11,12,13,14,15,16

			}
D21 =	{3,4,5,6,7,9,10,11,13,14,15,16}	D51 =	{1,2,3,4,5,6,8,10,11,12,14,15,16}
D23 =	{1,3,4,6,7,8,9,10,14,15,16}	D52 =	{1,2,3,4,5,6,8,10,11,12}
D24 =	{1,7,9,14,16}	D53 =	{1,2,3,4,5,6,7,8,10,11,12,14,16}
D25 =	{7,9,13,14,15,16}	D54 =	{1,3,4,5,6,8,9,11,12,16}
D26 =	{1,2,4,7,8,9,10,11,14,15,16}	D56 =	{1,2,4,5,6,7,8,9,10,11,12,14,15,16}
D27 =	{1,2,3,4,6,7,8,9,10,11,13,14,15,16}	D57 =	{1,2,3,4,5,6,8,9,10,11,12,13,14,15,16}
D31 =	{2,5,11,13,14,15}	D61 =	{3,5,6,12,13,14,15}
D32 =	{2,5,11,12,13}	D62 =	{3,5,6,12,13}
D34 =	{9,11}	D63 =	{1,3,5,6,7,10,12,13}
D35 =	{9,13,15}	D64 =	{1,3,4,6,13}
D36 =	{2,4,8,9,11,14,15,16}	D65 =	{3,13}
D37 =	{1,2,3,8,9,11,13,14,15,16}	D67 =	{1,2,3,6,11,12,13,14,15,16}
D71 =	{4,5,12,14}		
D72 =	{5,12}		
D73 =	{4,5,6,7,10,12}		
D74 =	{5,7}		
D75 =	{7}		
D76 =	{4,5,7,8,9,10}		

Once the concordance and discordance sets are found, concordance and discordance index can be calculated respectively. The concordance index can calculated using Equation (3.8) as follow:

C(1,2) =	0.486	C(3,1) =	0.826	C(5,1) =	0.071	C(7,1) =	0.777
C(1,3) =	0.174	C(3,2) =	0.847	C(5,2) =	0.136	C(7,2) =	0.947
C(1,4) =	0.473	C(3,4) =	0.965	C(5,3) =	0.047	C(7,3) =	0.675
C(1,5) =	0.929	C(3,5) =	0.953	C(5,4) =	0.215	C(7,4) =	0.919
C(1,6) =	0.174	C(3,6) =	0.639	C(5,6) =	0.073	C(7,5) =	0.960
C(1,7) =	0.223	C(3,7) =	0.325	C(5,7) =	0.040	C(7,6) =	0.641
C(2,1) =	0.514	C(4,1) =	0.527	C(6,1) =	0.826		
C(2,3) =	0.153	C(4,2) =	0.496	C(6,2) =	0.859		
C(2,4) =	0.504	C(4,3) =	0.035	C(6,3) =	0.361		
C(2,5) =	0.864	C(4,5) =	0.785	C(6,4) =	0.518		
C(2,6) =	0.141	C(4,6) =	0.482	C(6,5) =	0.927		
C(2,7) =	0.053	C(4,7) =	0.081	C(6,7) =	0.359		

The concordance matrix can be calculated using Equation (3.9) as follows:

C =

-	0.486	0.174	0.473	0.929	0.174	0.223
0.514	-	0.153	0.504	0.864	0.141	0.053
0.826	0.847	-	0.965	0.953	0.639	0.325
0.527	0.496	0.035	-	0.785	0.482	0.081
0.071	0.136	0.047	0.215	-	0.073	0.040
0.826	0.859	0.361	0.518	0.927	-	0.359
0.777	0.947	0.675	0.919	0.960	0.641	-

The discordance index can calculated using (3.10) as follow:

d(1,2) =	1.000	d(3,1) =	0.114	d(5,1) =	1.000	d(7,1) =	0.153
d(1,3) =	1.000	d(3,2) =	0.125	d(5,2) =	1.000	d(7,2) =	0.082
d(1,4) =	1.000	d(3,4) =	0.042	d(5,3) =	1.000	d(7,3) =	0.756
d(1,5) =	0.160	d(3,5) =	0.047	d(5,4) =	1.000	d(7,4) =	0.013
d(1,6) =	1.000	d(3,6) =	0.496	d(5,6) =	1.000	d(7,5) =	0.024
d(1,7) =	1.000	d(3,7) =	1.000	d(5,7) =	1.000	d(7,6) =	0.241
d(2,1) =	0.549	d(4,1) =	0.359	d(6,1) =	0.224		
d(2,3) =	1.000	d(4,2) =	0.610	d(6,2) =	0.187		
d(2,4) =	1.000	d(4,3) =	1.000	d(6,3) =	1.000		
d(2,5) =	0.210	d(4,5) =	0.100	d(6,4) =	1.000		
d(2,6) =	1.000	d(4,6) =	0.863	d(6,5) =	0.086		
d(2,7) =	1.000	d(4,7) =	1.000	d(6,7) =	1.000		

The discordance matrix can calculate using Equation (3.11) and shown as follows:

D =

-	1.000	1.000	1.000	0.160	1.000	1.000
0.549	-	1.000	1.000	0.210	1.000	1.000
0.114	0.125	-	0.042	0.047	0.496	1.000
0.359	0.610	1.000	-	0.100	0.863	1.000
1.000	1.000	1.000	1.000	-	1.000	1.000
0.224	0.187	1.000	1.000	0.086	-	1.000
0.153	0.082	0.756	0.013	0.024	0.241	-

The effective concordance matrix is calculated by determined average concordance index using Equation (3.12) as follows:

$$\bar{c} = \frac{21.000}{7(7-1)}$$

$$= 0.500$$

By using Equation (3.13), the effective concordance matrix or known as the Boolean matrix, E is calculating as follow:

$$E = \begin{vmatrix} - & 1 & 0 & 1 & 1 & 0 & 1 \\ 0 & - & 0 & 1 & 1 & 0 & 0 \\ 1 & 1 & - & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & - & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & - & 0 & 0 \\ 1 & 1 & 0 & 1 & 1 & - & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & - \end{vmatrix}$$

On contrary, average discordance index using Equation (3.14) as calculate below:

$$\bar{d} = \frac{26.441}{7(7-1)}$$

$$= 0.630$$

While, the effective discordance matrix or known as the Boolean matrix, F are calculate as follows using (3.15)

$$F = \begin{vmatrix} - & 1 & 0 & 0 & 1 & 0 & 0 \\ 0 & - & 0 & 1 & 1 & 0 & 0 \\ 1 & 1 & - & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & - & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & - & 0 & 0 \\ 1 & 1 & 0 & 1 & 1 & - & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & - \end{vmatrix}$$

After obtain the effective concordance matrix or Boolean matrix, E and effective discordance matrix or Boolean matrix, F, the next step is to get the ranking of the seven candidates. The ranking of seven candidates in selection of academic staff in this study are show in the next chapter.

4.4 Summary

This chapter detailed the development of the AHP and ELECTRE I model as a systematic evaluation model for the purpose of selecting the most appropriate academic staff in Faculty of Science. Besides depending on the Microsoft Excel and Expert Choice to accomplish the tedious calculation, the actual mathematical steps required in the manual calculation of one sub-criteria are shown in detail. This chapter also created the profiles of seven potential candidates. The qualities of all the candidates are rated comparatively based on the criteria and sub-criteria of the model.

CHAPTER 5

RESULTS AND DISCUSSION

5.1 Introduction

In this chapter, AHP and ELECTRE I model will be discussed in depth in selecting the most appropriate candidate to be the academic staff in Faculty of Science, UTM. The selection of academic staff is done by synthesizing the candidates' priority by implementing the AHP model as developed in previous chapter, while for the ELECTRE I model the most appropriate candidates is chosen by the ranking candidate using superiority.

This chapter also discussed the results for the ranking of the candidates based on the generated profiles using AHP and ELECTRE I model. For AHP method, the ranking of candidates is done by using Expert Choice 11.0. Examples of calculations to obtain the overall priority respect to goal are shown as well. By using Microsoft Excel 2007, ELECTRE I model will calculate the outranking matrix to rank the seven candidates for selection of academic staff.

5.2 Results for AHP Method

The ranking of the candidates are done using Expert Choice 11.0 to implement of AHP method in this study. Based on the priority weights synthesized, the discussion of the results is explained details.

5.2.1 Candidates Priority using Expert Choice 11.0

By using Expert Choice 11.0, the priority weight of candidates with respect to each of the criteria or sub-criteria can be synthesized after entering of the relative importance of each of the candidates into data grid. Figure 5.1 shows the priority weights synthesized for the ranking of candidates with respect to Education Background (EDU). From the bar chart shown, Candidate 7 has obtained the highest priority weight of 0.162, followed by Candidate 3 of 0.153, Candidate 6 of 0.148, Candidate 4 of 0.143, Candidate 2 of 0.138, Candidate 1 of 0.133 and Candidate 5 of 0.124. Therefore, Candidate 7 is the strongest in EDU compared to the rest of the candidates. The other priority weights of the seven candidates based on each criterion and sub-criteria in selecting the best candidates are similar with EDU.

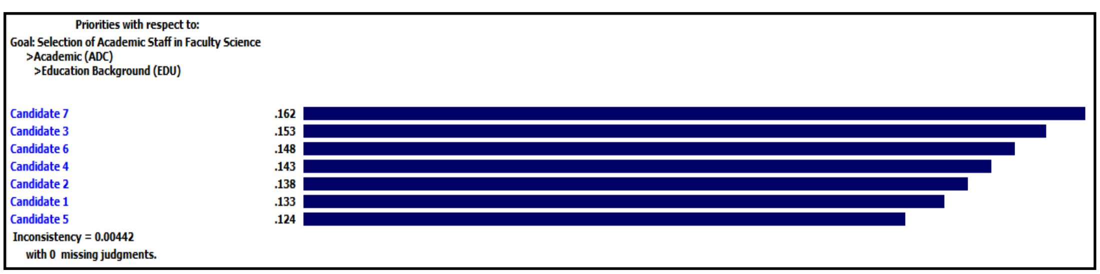


Figure 5.1 Priority weights of candidates synthesized with respect to EDU

Figure 5.2 shows the overall priority weights synthesized with respect to the goal to select the best candidate as academic staff in Faculty Science, UTM. From the bar chart shown, Candidate 7 has the highest priority weight of 0.155, followed by Candidate 3 of

0.151, Candidate 6 of 0.148, Candidate 1 of 0.141, Candidate 2 of 0.139, Candidate 4 of 0.137 and the lowest ranking is Candidate 5 of 0.129.

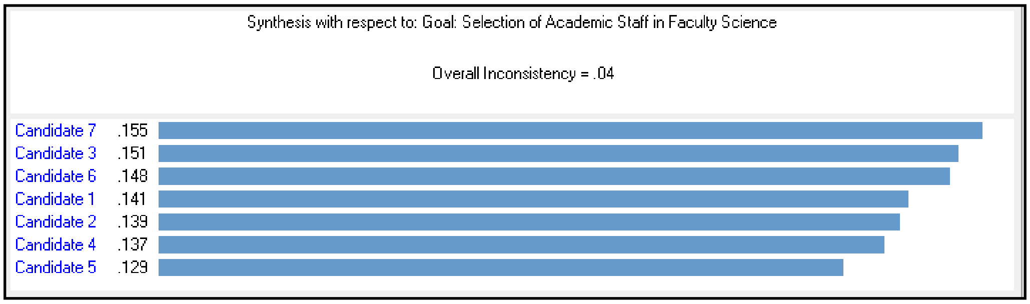


Figure 5.2 Priority weights of candidates synthesized with respect to Goal

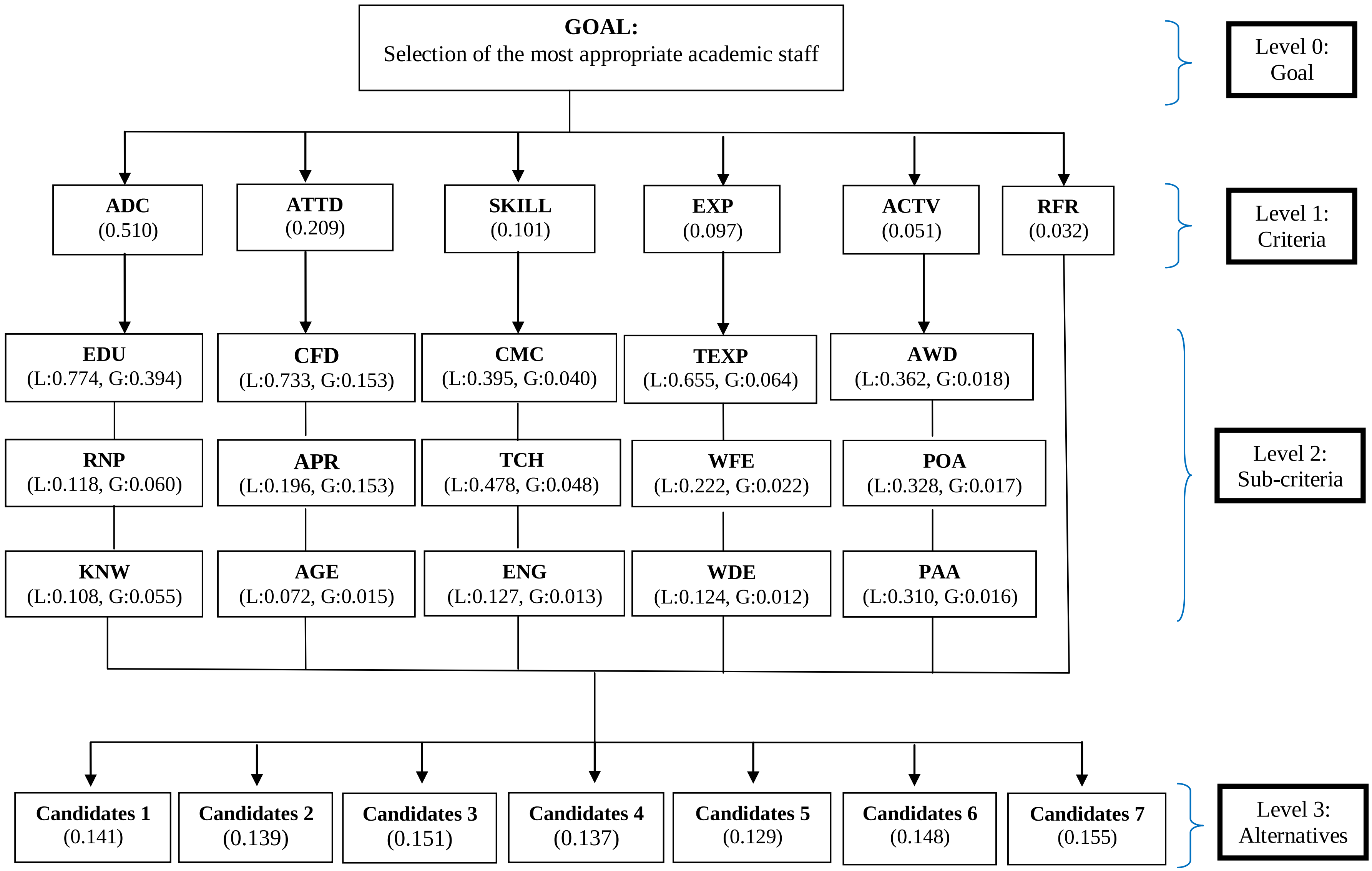


Figure 5.3 Hierarchy Tree with the Priority Weights

5.2.2 Calculation of Priority Weight

Figure 5.3 shows the hierarchy tree for the AHP model developed in this study with the priority weights for each of the criteria, sub-criteria and the candidates. By referring to the priority weight synthesized in Figure 5.3, the calculation of the priority of each of the criteria can be done.

There are two types of priority weights shown for each of the sub-criteria at level 2, which is local priority and global priority. Local priority does not show the importance of the sub-criteria for the overall selection process. As example, the local priority weight for EDU is 0.774, but the global priority weight is 0.394. Its mean that the importance of EDU is contributing 39.4% to the overall selection process, but the contributing of EDU to ADC is 77.4%. The global priority of sub-criteria equals the local priority of sub-criteria times global priority of criteria. The following Table 5.1 shows the calculation to obtain the global priority for sub-criteria of ADC.

Table 5.1 Calculation of global priority weight of ADC

Sub-criteria of ADC	Local priority weight	Global priority weight
EDU	0.774	0.774 x 0.510 = 0.394
RNP	0.118	0.118 x 0.510 = 0.060
KNW	0.108	0.108 x 0.510 = 0.055

From the Table 5.1 above, we can calculate the Total Global Priority for sub-criteria of ADC by summing all of the global priority weight of each sub-criteria of ADC as follows:

Total Global Priority for sub-criteria of ADC

= 0.394 + 0.060 + 0.055

= 0.510

5.2.2.1 Calculation of priority candidate with respect to ADC

The calculation of the priority of each of the candidates can be done by refer to the local sub-criteria weights synthesized as shown in Figure 4.7 in Chapter 4 and the priority weights of candidates for each sub-criteria. The following examples show the details of the calculation for the candidate priority weights with respect to criteria.

Table 5.2 Candidate priority weights synthesized with respect to ADC

Sub-criteria of ADC	Local Priority of Sub-criteria, p_j	Priority Weight of Candidate 1, q_{1i}	Priority Weight of Candidate 3, q_{3i}
EDU	0.774	0.133	0.153
RNP	0.118	0.144	0.133
KNW	0.108	0.148	0.159
ADC	**0.510**	**0.136**	**0.151**

Let $p_j, j = 1,2,3$ be the weights of the 3 sub-criteria and $q_{ij}, j = 1,2, \dots 7$ are the priority weights of the 7 candidates on the sub-criteria $j, j = 1,2,3$. The weights of the 7 candidates with respect to ADC can be obtained as:

$$w_i = \sum_{j=1}^{3} p_j q_{ij} \quad i = 1,2, \dots 7 \qquad (5.1)$$

The calculation of priority weight with respect to the criteria of ADC for candidate 1 and 3 can be obtained by using Equation (5.1) are shown as follows::

Priority weight for Candidate 1 with respect to ADC

$= p_1 q_{11} + p_2 q_{12} + p_3 q_{13}$

$= 0.774(0.133) + 0.118(0.144) + 0.108(0.148)$

$= 0.136$

Priority weight for Candidate 3 with respect to ADC

$= p_1 q_{31} + p_2 q_{32} + p_3 q_{33}$

$= 0.774(0.153) + 0.118(0.133) + 0.108(0.159)$

$= 0.151$

The priority weights for the criteria of ATTD, SKILL, EXP, ACTV and RFR for each of the candidates can be obtained by using the same method as shown above.

5.2.2.2 Calculation of Overall Priority with Respect to Goal

The calculation of the overall priority of each of the candidates with respect to Goal can be done by referring the priority of criteria synthesized as shown in Figure 4.7 in Chapter 4 and the priority weights of candidates with respect to criteria. The following examples show the details of the calculation for the candidate priority weights with respect to Goal.

Table 5.3 Priority weights of the criteria for Candidate 1 and Candidate 3

Criteria	Priority of Criteria, p_j	Priority weight of Candidate 1, q_{1j}	Priority weight of Candidate 3, q_{3j}
ADC	0.510	0.136	0.151
ATTD	0.209	0.150	0.151
SKILL	0.101	0.132	0.156
EXP	0.097	0.146	0.154
ACTV	0.051	0.158	0.137
RFR	0.032	0.145	0.143
GOAL	**-**	**0.141**	**0.151**

Combine the priority of criteria and priority of each candidate can get the overall priority ranking of the candidates. Let $p_j, j = 1,2, \dots 6$ be the weights of the 6 criteria and $q_{ij}, i = 1,2, \dots 7$ are the priority weights of the 7 candidates for the 6 criteria $j, j = 1,2, \dots 6$. The priority of the 7 candidates with respect to Goal can be calculated by using formula (5.2):

$$w_i = \sum_{j=1}^{6} p_j q_{ij}, \quad i = 1,2, \dots 7 \qquad (5.2)$$

The calculation for finding the overall priority with respect to the Goal for Candidate 1 and Candidate 3 are given below:

Priority weight for Candidate 1 with respect to Goal, w_1

$$= p_1 q_{11} + p_2 q_{12} + p_3 q_{13} + p_4 q_{14} + p_5 q_{15} + p_6 q_{16}$$

$$= 0.510(0.136) + 0.209(0.150) + 0.101(0.132) + 0.097(0.146) + 0.051(0.158) + 0.032(0.145)$$

$$= 0.141$$

Priority weight for Candidate 3 with respect to Goal, w_3

$$= p_1 q_{31} + p_2 q_{32} + p_3 q_{33} + p_4 q_{34} + p_5 q_{35} + p_6 q_{36}$$

$$= 0.510(0.151) + 0.209(0.151) + 0.101(0.156) + 0.097(0.154) + 0.051(0.137) + 0.032(0.143)$$

$$= 0.151$$

The calculation of priority weight with respect to the Goal for Candidate 2, Candidate 4, Candidate 5, Candidate 6, and Candidate 7 can be obtained by using the same method as shown above. The overall priority weights of each candidate with respect to the Goal to select the best candidate as academic staff in Faculty Science, UTM are shown in Table 5.4.

Table 5.4 Priority Weight of Candidates Respect to Goal

	Priority Weight respect to Goal
Candidate 1	0.141
Candidate 2	0.139
Candidate 3	0.151
Candidate 4	0.137
Candidate 5	0.129
Candidate 6	0.148
Candidate 7	0.155

From Table 5.4, the priority weight for each candidate is sorted in descending order. The result shown that Candidate 7 was the highest priority weight of 0.155, followed by Candidate 3 of 0.151, Candidate 6 of 0.148, Candidate 1 of 0.141, Candidate 2 of 0.139, Candidate 4 of 0.137 and the lowest ranking is Candidate 5 of 0.129.

From the result, it can be seen that Candidate 7 score the highest priority weight according to the ranking using AHP model developed in this study. The result of priority weights of the seven candidates further reveals that the order of these alternatives in this study is Candidate 7 > Candidate 3 > Candidate 6 > Candidate 1 > Candidate 2 > Candidate 4 > Candidate 5.

5.3 Results and Analysis for ELECTRE I Method

In this section, by using Microsoft Excel 2007 the ranking of seven candidates based on each of the sub-criteria is done by implementation of ELECTRE I method. Based on the superiority synthesized from ELECTRE I, the selection of best academic staff are explained in details.

5.3.1 Outranking Matrix of Candidates

The calculations of the effective concordance matrix and effective discordance matrix obtained from chapter 4 are used to calculate the outranking matrix in this section. The effective concordance matrix or Boolean matrix, E and effective discordance matrix or Boolean matrix, F is used to convert the results of each concordance matrix and discordance matrix to zero and one.

The candidates then ranked using the outranking matrix (H) which is founds by an element-to-element product of the Boolean matrix, E and Boolean matrix, F. The calculation of common elements ($h_{k,l}$) construct outranking matrix (H) from matrix E and matrix F, which is $e_{k,l}$ and $f_{k,l}$ are elements of matrix E and elements of matrix F respectively are shows as follow:

$$H = E \times F$$

$$h_{k,l} = e_{k,l} \times f_{k,l}$$

$$H = \begin{bmatrix} - & 1 & 0 & 1 & 1 & 0 & 1 \\ 0 & - & 0 & 1 & 1 & 0 & 0 \\ 1 & 1 & - & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & - & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 1 & 1 & - & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & - \end{bmatrix} \times \begin{bmatrix} - & 1 & 0 & 0 & 1 & 0 & 0 \\ 0 & - & 0 & 1 & 1 & 0 & 0 \\ 1 & 1 & - & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & - & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 1 & 1 & - & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & - \end{bmatrix}$$

$$= \begin{bmatrix} - & 1 & 0 & 0 & 1 & 0 & 0 \\ 0 & - & 0 & 1 & 1 & 0 & 0 \\ 1 & 1 & - & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & - & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 1 & 1 & - & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & - \end{bmatrix}$$

The outranking matrix (H) indicates the order of relative superiority of candidates which means that if $h_{k,l} = 1$, indicates that A_k is superior to A_l in terms of both concordance and discordance index. From the matrix (H) above, the element of $h_{1,2} = 1$ means that Candidate 1 is superior to Candidate 2.

For the ranking of each candidate, the total amount of number 1 in each column and row from matrix (H) are calculate respectively. The calculation of total amount of number 1 in each column and row are shown below. The columns of matrix (H) which have the least amount of number 1 should be chosen as the best one. In the case where the amount of number 1 in any two columns of matrix (H) are the same, the option that have the largest amount of number 1 in rows of matrix (H) is preferred for purposes. The ranking of the seven candidates based on the amount of number 1 of each column and row of matrix (H) is done in the following Table 5.5:

Total of number 1 (Row)

$$H = \begin{bmatrix} - & 1 & 0 & 0 & 1 & 0 & 0 \\ 0 & - & 0 & 1 & 1 & 0 & 0 \\ 1 & 1 & - & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & - & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 1 & 1 & - & 0 \\ 1 & 1 & 1 & 1 & 1 & 1 & - \end{bmatrix} \qquad \begin{matrix} 2 \\ 2 \\ 5 \\ 1 \\ 0 \\ 4 \\ 6 \end{matrix}$$

Total of number 1 (Column) $\quad 3 \quad 4 \quad 1 \quad 4 \quad 5 \quad 2 \quad 0$

Table 5.5 The amount of number 1 in column and row for each candidate

	Amount of number 1 in Column	Amount of number 1 in Row
Candidate 1	3	2
Candidate 2	4	2
Candidate 3	1	5
Candidate 4	4	1
Candidate 5	6	0
Candidate 6	2	4
Candidate 7	0	6

Table 5.6 shows the overall ranking of seven candidates to select most appropriate academic staff. The overall rankings of candidates are obtained based on the amount of number 1 in each column and row respectively as shown in Table 5.5.

Table 5.6 Ranking of seven candidates

	Ranking of Candidate
Candidate 1	4
Candidate 2	5
Candidate 3	2
Candidate 4	6
Candidate 5	7
Candidate 6	3
Candidate 7	1

Table 5.6 above shows the overall ranking with respect to each candidate to select the best academic staff in Faculty Science, UTM. From Table 5.6, it is shown that Candidate 7 is ranked the first because the amount of number 1 in column the less compared to other candidate. It follows by Candidate 3 which has only one amount of number 1 in column, Candidate 6 which has two amount of number 1 in column, and then, Candidate 1 which has three amount of number 1 in column. Since Candidate 2 and Candidate 4 have same amount of number 1 in column but Candidate 2 has larger amount of number 1 in row compared to Candidate 4 which has only one amount of number 1 in row, therefore Candidate 2 is chosen first followed by Candidate 4. The last ranking of candidates is Candidate 5, which has a largest amount of number 1 in column and smallest amount of number 1 in row. The order of all these alternatives in this study is Candidate 7 > Candidate 3 > Candidate 6 > Candidate 1 > Candidate 2 > Candidate 4 > Candidate 5.

5.4 The Comparison of Methods

The AHP method is basically composed of two steps. Firstly, we need to determine the relative priority of the criteria or sub-criteria. Then, we determine the relative priority of each candidate. On the other hand, the construction of an outranking relation of ELECTRE I method is based on two major concepts that is concordance and discordance. Both AHP and ELECTRE I method proceeds to a pair-wise comparison of candidates in each single criterion in order to determine the strength of preference of one candidate over the others.

The application method develops in this study is a hierarchy structure of the problem in term of the overall goal, the criteria and the decision of alternatives, which gives clear and formal structure of the situation.

In this study, the process of selection academic staff in Faculty of Science, UTM are more effective by applying both AHP and ELECTRE I method using decision making process. The application of AHP and ELECTRE I methods in this study are free from biasness, as the existing methods are biased to individual value judgments. There is possibility that the normal practiced selection processes are subjected to inefficient procedures and biasness of those in the selection committee.

Both methods applied in this study are more scientific and reasonable method for selection compared to the existing method that is usually influenced by the nature, attitude and experience of the individuals who are involved in the process of selection academic staff.

Each method AHP and ELECTRE I reflects a different approach to solve MADM problems. However, both methods produces same ranking of candidates. For ELECTRE I method, it is elicits from the decision makers a concordance and discordance index for each pair of alternatives. While, AHP method deals with matrix that constructed using the relative importance of the alternatives in term of each criterion.

By using MADM method, decision that is more effective can be made because this method is more standardized or established selection model based on the scale introduced (Saaty, 2008). The existing method is calculated based on the average given from different interviewers that are involved in the process of selection. In existing methods, each candidate will be scored based on each criterion where each criterion has the same marks. The scores of each candidate will be given without comparing scores with other candidate. Then, the candidate with the highest scores will be selected as successful candidate.

AHP and ELECTRE method is the effective methods for MADM with qualitative and quantitative features. The method presented in this study will allow the users to rank their existing alternatives more efficiently and easily. Its help improve the traditional method and simplify the process of selecting the best candidate to become the academic member in this study by considering the criteria that may influence the decision made.

Both methods of AHP and ELECTRE I have different steps in calculation to obtain the best candidates. However, these two methods give the same ranking of each candidate and choose the similar best candidate. From the result that we get in this study, it shows that both AHP and ELECTRE I method give the same result that is Candidate 7 is selected as the most appropriate candidate to be an academic staff in Faculty of Science, UTM.

Several field studies have compared AHP method to one or more of the other methods. Karni et al (1990) in his study concluded that the AHP and MCDM method rankings did not differ significantly in three real life case studies. The three case studies are Evaluating Bank Branches, Locating a Financial Planning Agency, and Selecting a Winner for a Faculty Merit Award.

We can conclude that both AHP and ELECTRE I method rankings did not differ significantly in this study. As stated by Lootsma (1990), contrasted AHP and ELECTRE method as representing the American and French schools in MCDM thought found to be unexpectedly close to each other. However, it is impossible to determine precisely the best decision making method. This problem of finding the best decision making method always reaches a decision-making paradox which makes any attempt in solving this problem to be of limited success (Triantaphyllou and Mann, 1989).

From the application of the two methods in this study, we can state that there are differences steps and calculation between AHP and ELECTRE I method, but it is not obvious that one method is better than the other, which is both method produce same result.

5.5 Summary

It is important to select an appropriate academic staff for a university to ensure the standard quality and success of a university. Therefore, there is a need to develop a suitable and effective model to improve the existing academic staff selection model in the university. The intent of this study is to show the application of a model that is not overly complex and that does legitimately aggregate across scales that can serve to formalize a decision process, reduce time commitments, create a process orientation, documents the strategy and result in better decisions.

From the result, it can be seen that Candidate 7 is ranked first, followed by Candidate 3, Candidate 6, Candidate 1, Candidate 2, Candidate 4, and lastly Candidate 5. Therefore, Faculty of Science should choose Candidate 7 as the academic staff as it ranked first for both AHP and ELECTRE I method in this study.

CHAPTER 6

SUMMARY AND CONCLUSION

6.1 Introduction

This chapter presents a summary of the work done throughout this study. It includes the summary and conclusion of the study. This chapter also includes some recommendations for further studies in this area.

6.2 Summary

This study concentrates on the application of AHP and ELECTRE I method in selection of academic staff in Faculty of Science, UTM.

In Chapter 2, we provided an overview of academic staff selection, MCDM, AHP and ELECTRE I method. In academic staff selection, the selection criterion is the important part to ensure that the best candidate fulfills the criteria for that position. Besides that, the application of AHP and ELECTRE I method from previous researches were also discussed.

Chapter 3 discussed data acquisition which includes the interviews with deputy registrar from Registrars' Office and assistant registrar from Faculty of Science to obtain information about criteria of academic staff selection. The most important part in this chapter is the description of AHP and ELECTRE I which was discussed in details.

In Chapter 4, the application of AHP and ELECTRE I method are explained. By using geometric mean, the pair-wise comparison for each of the criteria and sub-criteria are formed. The manual calculation of priority of each criterion is done and we need to check the consistency of the criteria, which is C.R must be less than 0.1. By using Expert Choice 11.0, ranking of the results can be done by transforming simulated profile from the quantitative data in pair-wise comparison to the data grid. While for ELECTRE I method, it starts by evaluating each candidate with respect to each sub-criteria. ELECTRE I uses concordance and discordance indices to analyze outranking relations among different candidate and choose the best candidate using outranking matrix.

In Chapter 5, the ranking of the candidates based on the generated profiles by applying AHP and ELECTRE I model using Expert Choice 11.0 and Microsoft Excel 2007 respectively was done. For AHP method, the manual calculation for priority of criteria and overall priority of candidates with respect to goal was done. The overall priority of candidate with respect to goal shows that the order of the candidates in this study is Candidate 7 > Candidate 3 > Candidate 6 > Candidate 1 > Candidate 2 > Candidate 4 > Candidate 5. While for ELECTRE I method, the rank of the candidates using the outranking matrix (H) found by multiplying Boolean matrix, E and Boolean matrix, F gives the order of the candidate that is Candidate 7 > Candidate 3 > Candidate 6 > Candidate 1 > Candidate 2 > Candidate 4 > Candidate 5. From the application of both methods, there are differences in steps and calculation to select the best candidate, but they produce the same result: Candidate 7 is selected as academic staff.

6.3 Conclusion

In this study, we have applied a decision making model by using AHP and ELECTRE I method for academic staff selection process in Faculty of Science, UTM. Both methods applied in this study consider both qualitative and quantitative approaches to research. The problem is decomposed into a hierarchy of goals, criteria, sub-criteria and candidates. This is the most creative and important part of decision making. Structuring the decision problem as hierarchy is fundamental to the process of both methods.

Basically, AHP method helps in structuring the complexity, measurement and synthesis of rankings. These features make it suitable for a wide variety of application. AHP has found ready acceptance by decision makers due to its simplicity and ease of use. It helps structure the decision makers thoughts and can help in organizing the problem in a manner that is simple to follow and analyze. The AHP is analytic process. Its help in analyzing the decision problem on a logical footing and assists in converting decision makers' intuition and gut feelings into numbers which can be openly questioned by others and can also be explained to others.

The ELECTRE I method is chosen in this study because it provides a simple and understandable analysis of the concordance index. Concordance index can be seen as measuring the arguments in favour of 'A outranks B'. The ELECTRE I method has several unique features: these are the concept of outranking. This method was well received by the decision makers and provided sensible and straightforward ranking.

The decision in this study will be more scientific and reasonable because this method is more standardized or established selection model by using AHP and ELECTRE I in the process of academic staff selection in Faculty of Science, UTM.

The method presented in this study will allow the users to rank their existing alternatives more efficiently and easily. Its help improve the traditional method and simplify the process of a selecting a best candidate to become the academic member in this study by considering the criteria that may influence the decision made.

In this study, the AHP and ELECTRE I methods applied in this study are free from biases which make the process of selection academic staff are more effective by applying both AHP and ELECTRE I method. There is possibility that the normal practiced selection process is subjected to inefficient procedures and biasness of those in the selection committee.

From the application of AHP and ELECTRE I methods in this study, we can conclude that both methods have are different steps in calculation, but it is not obvious that one method is better than others. This indicates that these two methods give the same ranking of each candidate and choose the similar best candidate. The result from this study shows that both AHP and ELECTRE I method give the same result which is Candidate 7 are selected as the most appropriate candidate to be an academic staff in Faculty of Science, UTM.

As a result of this study, Candidate 7 is determined as the best alternative which is ranked first for both AHP and ELECTRE I method. Candidate 7 is selected based on the relative judgments made by experts in the knowledge acquisition process as described in Chapter 3. The experiences and knowledge of experts is vital in the determination of the priority weight of criteria and sub-criteria to produce the consistent result in the selection process.

We can conclude that the selection of academic staff in Faculty of Science, UTM can be select accurately by using AHP and ELECTRE I method. By applying both methods, the selection committee can save time and minimize consumption of resources during the selection process. Therefore, we highly recommend that the Faculty of Science, UTM to adopt the two MCDM methods in academic staff selection as discussed in this study. Otherwise, this study also proven that the two methods in MCDM namely AHP and ELECTRE I method produce the same ranking of result.

6.4 Recommendation

In this research, we have applied the AHP and ELCTRE I method in selection of academic staff in Faculty of Science, UTM. In the future, we would recommend that:

1. The other researchers could also applied other MCDM method in selecting academic staff such as MAUT, TOPSIS or PROMETHEE.

2. The focus of future studies will concentrate on other ELECTRE methods such as ELECTRE II and ELECTRE III method to select the best academic staff.

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APPENDIX A

SAMPLE OF DOCUMENTS OBTAINED FROM KNOWLEDGE ACQUISITION

PAIR-WISE COMPARISON TABLE

Table 4.8 Pair-wise comparison of candidate profile for sub-criteria of ADC: EDU

	Candidate 1	Candidate 2	Candidate 3	Candidate 4	Candidate 5	Candidate 6	Candidate 7
Candidate 1	1.000	0.792	1.063	0.665	0.924	1.132	1.022
Candidate 2	1.263	1.000	1.112	1.142	1.221	1.181	1.091
Candidate 3	0.941	0.899	1.000	1.081	0.898	1.042	0.932
Candidate 4	1.503	0.876	0.925	1.000	1.024	1.391	0.926
Candidate 5	1.082	0.819	1.114	0.977	1.000	1.280	0.824
Candidate 6	0.883	0.847	0.960	0.719	0.781	1.000	0.960
Candidate 7	0.978	0.917	1.073	1.080	1.214	1.042	1.000

Table 4.9 Pair-wise comparison of candidate profile for sub-criteria of ADC : RNP

	Candidate 1	Candidate 2	Candidate 3	Candidate 4	Candidate 5	Candidate 6	Candidate 7
Candidate 1	1.000	0.832	0.941	1.131	1.191	1.212	0.840
Candidate 2	1.202	1.000	1.182	1.212	1.172	1.190	1.032
Candidate 3	1.063	0.846	1.000	1.122	1.203	1.242	1.370
Candidate 4	0.884	0.825	0.891	1.000	1.071	1.023	0.883
Candidate 5	0.840	0.853	0.831	0.934	1.000	0.979	0.869
Candidate 6	0.825	0.840	0.805	0.978	1.021	1.000	0.915
Candidate 7	1.190	0.969	0.730	1.133	1.151	1.093	1.000

Table 4.10 Pair-wise comparison of candidate profile for sub-criteria of ADC : KNW

	Candidate 1	Candidate 2	Candidate 3	Candidate 4	Candidate 5	Candidate 6	Candidate 7
Candidate 1	1.000	0.969	1.042	0.916	1.082	1.132	1.152
Candidate 2	1.032	1.000	1.061	0.923	1.112	1.142	1.163
Candidate 3	0.960	0.943	1.000	0.899	1.031	1.104	1.211
Candidate 4	1.092	1.083	1.112	1.000	1.144	1.163	1.221
Candidate 5	0.924	0.899	0.970	0.874	1.000	1.092	1.113
Candidate 6	0.883	0.877	0.906	0.860	0.916	1.000	1.012
Candidate 7	0.658	0.860	0.826	0.819	0.898	0.988	1.000

Table 4.11 Pair-wise comparison of candidate profile for sub-criteria of ATTD : CFD

	Candidate 1	Candidate 2	Candidate 3	Candidate 4	Candidate 5	Candidate 6	Candidate 7
Candidate 1	1.000	1.082	0.932	1.143	0.969	1.134	0.950
Candidate 2	0.924	1.000	0.980	1.162	1.061	1.081	0.933
Candidate 3	1.073	1.021	1.000	0.890	1.102	1.072	0.890
Candidate 4	0.875	0.861	1.124	1.000	1.231	1.210	1.013
Candidate 5	1.032	0.943	0.907	0.812	1.000	1.121	0.951
Candidate 6	0.882	0.925	0.933	0.826	0.892	1.000	0.892
Candidate 7	1.053	1.072	1.124	0.987	1.052	1.121	1.000

Table 4.12 Pair-wise comparison of candidate profile for sub-criteria of ATTD : APR

	Candidate 1	Candidate 2	Candidate 3	Candidate 4	Candidate 5	Candidate 6	Candidate 7
Candidate 1	1.000	1.263	1.224	1.112	1.134	1.282	1.142
Candidate 2	0.792	1.000	0.898	0.853	0.916	1.113	0.890
Candidate 3	0.817	1.113	1.000	0.892	0.978	1.221	0.924
Candidate 4	0.899	1.172	1.121	1.000	1.213	1.264	1.131
Candidate 5	0.882	1.092	1.022	0.824	1.000	1.112	0.940
Candidate 6	0.780	0.898	0.819	0.791	0.899	1.000	0.891
Candidate 7	0.876	1.123	1.082	0.884	1.064	1.122	1.000

Table 4.13 Pair-wise comparison of candidate profile for sub-criteria of ATTD : AGE

	Candidate 1	Candidate 2	Candidate 3	Candidate 4	Candidate 5	Candidate 6	Candidate 7
Candidate 1	1.000	0.978	1.082	0.898	1.103	1.142	1.132
Candidate 2	1.023	1.000	1.103	0.960	1.124	1.204	1.182
Candidate 3	0.924	0.907	1.000	0.906	1.092	1.153	1.204
Candidate 4	1.113	1.042	1.104	1.000	1.163	1.223	1.253
Candidate 5	0.907	0.890	0.916	0.860	1.000	1.112	1.092
Candidate 6	0.876	0.831	0.867	0.818	0.899	1.000	0.970
Candidate 7	0.883	0.846	0.831	0.798	0.916	1.031	1.000

Table 4.14 Pair-wise comparison of candidate profile for sub-criteria of SKILL : CMC

	Candidate 1	Candidate 2	Candidate 3	Candidate 4	Candidate 5	Candidate 6	Candidate 7
Candidate 1	1.000	0.907	1.202	0.825	1.123	0.853	0.786
Candidate 2	1.103	1.000	1.191	0.845	1.113	0.923	0.934
Candidate 3	0.832	0.840	1.000	0.799	0.831	0.862	0.867
Candidate 4	1.212	1.183	1.252	1.000	1.231	1.121	0.959
Candidate 5	0.890	0.898	1.204	0.812	1.000	0.932	0.840
Candidate 6	1.172	1.083	1.160	0.892	1.073	1.000	0.951
Candidate 7	1.272	1.071	1.154	1.043	1.190	1.052	1.000

Table 4.15 Pair-wise comparison of candidate profile for sub-criteria of SKILL : TCH

	Candidate 1	Candidate 2	Candidate 3	Candidate 4	Candidate 5	Candidate 6	Candidate 7
Candidate 1	1.000	0.825	0.875	0.831	0.969	1.061	0.805
Candidate 2	1.212	1.000	1.162	0.933	1.213	1.252	0.861
Candidate 3	1.143	0.861	1.000	0.906	1.132	1.204	0.831
Candidate 4	1.203	1.072	1.104	1.000	1.203	1.233	0.951
Candidate 5	1.032	0.824	0.883	0.831	1.000	1.174	0.907
Candidate 6	0.943	0.799	0.831	0.811	0.852	1.000	0.883
Candidate 7	1.243	1.162	1.204	1.051	1.103	1.132	1.000

Table 4.16 Pair-wise comparison of candidate profile for sub-criteria of SKILL : ENG

	Candidate 1	Candidate 2	Candidate 3	Candidate 4	Candidate 5	Candidate 6	Candidate 7
Candidate 1	1.000	0.876	1.273	0.719	0.861	1.382	0.740
Candidate 2	1.142	1.000	1.382	1.052	0.917	0.818	0.934
Candidate 3	0.786	0.724	1.000	0.884	0.951	0.861	0.811
Candidate 4	1.391	0.951	1.131	1.000	0.898	0.831	0.762
Candidate 5	1.162	1.091	1.052	1.113	1.000	1.000	0.884
Candidate 6	0.724	1.223	1.161	1.204	1.000	1.000	0.949
Candidate 7	1.352	1.071	1.233	1.312	1.131	1.054	1.000

Table 4.17 Pair-wise comparison of candidate profile for sub-criteria of EXP : TEXP

	Candidate 1	Candidate 2	Candidate 3	Candidate 4	Candidate 5	Candidate 6	Candidate 7
Candidate 1	1.000	0.933	1.103	0.824	1.182	1.091	0.876
Candidate 2	1.072	1.000	1.141	0.845	1.093	1.052	0.917
Candidate 3	0.907	0.876	1.000	0.831	1.191	1.104	0.941

Candidate 4	1.213	1.184	1.203	1.000	1.224	1.173	1.091
Candidate 5	0.846	0.915	0.840	0.817	1.000	0.924	0.876
Candidate 6	0.917	0.951	0.906	0.853	1.082	1.000	0.898
Candidate 7	1.142	1.090	1.063	0.917	1.141	1.114	1.000

Table 4.18 Pair-wise comparison of candidate profile for sub-criteria of EXP : WFE

	Candidate 1	Candidate 2	Candidate 3	Candidate 4	Candidate 5	Candidate 6	Candidate 7
Candidate 1	1.000	0.762	1.253	1.313	1.473	1.264	0.763
Candidate 2	1.312	1.000	1.291	1.504	1.061	1.392	0.979
Candidate 3	0.798	0.775	1.000	1.251	1.153	1.354	0.840
Candidate 4	0.762	0.665	0.799	1.000	0.883	1.312	0.819
Candidate 5	0.679	0.943	0.867	1.133	1.000	1.123	0.932
Candidate 6	0.791	0.718	0.739	0.762	0.890	1.000	0.805
Candidate 7	1.311	1.021	1.190	1.221	1.073	1.242	1.000

Table 4.19 Pair-wise comparison of candidate profile for sub-criteria of EXP : WDE

	Candidate 1	Candidate 2	Candidate 3	Candidate 4	Candidate 5	Candidate 6	Candidate 7
Candidate 1	1.000	0.960	1.133	0.898	1.163	1.204	1.182
Candidate 2	1.042	1.000	1.121	0.924	1.104	1.121	1.091
Candidate 3	0.752	0.892	1.000	0.890	1.063	1.103	1.052
Candidate 4	1.114	1.082	1.123	1.000	1.122	1.174	1.193
Candidate 5	0.860	0.906	0.941	0.891	1.000	1.081	0.916
Candidate 6	0.830	0.892	0.907	0.852	0.925	1.000	0.884
Candidate 7	0.846	0.917	0.951	0.838	1.092	1.131	1.000

Table 4.20 Pair-wise comparison of candidate profile for sub-criteria of ACTV : AWD

	Candidate 1	Candidate 2	Candidate 3	Candidate 4	Candidate 5	Candidate 6	Candidate 7
Candidate 1	1.000	0.818	1.011	1.321	1.442	0.786	1.421
Candidate 2	1.223	1.000	1.242	1.382	1.550	1.000	1.563
Candidate 3	0.989	0.805	1.000	0.847	1.363	0.867	1.282
Candidate 4	0.757	0.724	1.180	1.000	1.312	0.640	1.150
Candidate 5	0.693	0.645	0.734	0.762	1.000	0.818	1.374
Candidate 6	1.273	1.000	1.153	1.562	1.223	1.000	1.562
Candidate 7	0.704	0.640	0.780	0.870	0.727	0.640	1.000

Table 4.21 Pair-wise comparison of candidate profile for sub-criteria of ACTV : POA

	Candidate 1	Candidate 2	Candidate 3	Candidate 4	Candidate 5	Candidate 6	Candidate 7
Candidate 1	1.000	1.112	1.213	1.123	1.252	1.223	1.052
Candidate 2	0.899	1.000	1.201	1.142	1.190	1.211	0.969
Candidate 3	0.824	0.833	1.000	0.824	0.853	0.840	0.817
Candidate 4	0.890	0.876	1.213	1.000	1.183	1.132	0.899
Candidate 5	0.799	0.840	1.172	0.845	1.000	0.940	0.891
Candidate 6	0.818	0.826	1.190	0.883	1.064	1.000	0.917
Candidate 7	0.951	1.032	1.224	1.112	1.122	1.090	1.000

Table 4.22 Pair-wise comparison of candidate profile for sub-criteria of ACTV : PAA

	Candidate 1	Candidate 2	Candidate 3	Candidate 4	Candidate 5	Candidate 6	Candidate 7
Candidate 1	1.000	1.113	1.223	1.172	1.202	1.152	1.132
Candidate 2	0.898	1.000	1.204	1.190	1.231	1.141	1.109
Candidate 3	0.818	0.831	1.000	0.925	1.091	0.891	0.853
Candidate 4	0.853	0.840	1.081	1.000	1.134	0.898	0.867
Candidate 5	0.832	0.812	0.917	0.882	1.000	0.874	0.861
Candidate 6	0.868	0.876	1.122	1.113	1.144	1.000	0.951
Candidate 7	0.883	0.906	1.172	1.153	1.162	1.051	1.000

Table 4.23 Pair-wise comparison of candidate profile for criteria of RFR

	Candidate 1	Candidate 2	Candidate 3	Candidate 4	Candidate 5	Candidate 6	Candidate 7
Candidate 1	1.000	0.876	1.171	1.103	0.831	1.122	1.042
Candidate 2	1.142	1.000	1.142	1.071	1.131	1.203	1.123
Candidate 3	0.854	0.876	1.000	0.868	0.917	0.853	0.831
Candidate 4	0.907	0.934	1.152	1.000	1.142	1.021	0.917
Candidate 5	1.204	0.884	1.091	0.876	1.000	1.042	0.891
Candidate 6	0.891	0.831	1.173	0.979	0.960	1.000	1.081
Candidate 7	0.960	0.890	1.204	1.091	1.122	0.925	1.000