KADIR HAS UNIVERSITY

GRADUATE SCHOOL OF SCIENCE AND ENGINEERING

A FUZZY AHP APPROACH FOR FINANCIAL PERFORMANCE EVALUATION OF AIRLINE COMPANIES

SİNEM GÜREL

2012

A FUZZY AHP APPROACH FOR FINANCIAL PERFORMANCE EVALUATION OF AIRLINE COMPANIES

Sinem GÜREL

B.S., Industrial Engineering, Kadir Has University, 2007

M.S., Industrial Engineering, Kadir Has University, 2012

Submitted to the Graduate School of Science and Engineering

in partial fulfillment of the requirements for the degree of

Master of Engineering in Industrial Engineering

KADIR HAS UNIVERSITY

2012

KADIR HAS UNIVERSITY

GRADUATE SCHOOL OF SCIENCE AND ENGINEERING

A FUZZY AHP APPROACH FOR FINANCIAL PERFORMANCE EVALUATION OF AIRLINE COMPANIES

SİNEM GÜREL

APPROVED BY:

Assoc. Prof. Dr. Zeki AYAĞ ______________________

(Thesis Supervisor)

Assisst. Prof. Dr. Funda SAMANLIOĞLU ______________________

Assoc. Prof. Dr. Rıfat Gürcan ÖZDEMİR ______________________

APPROVAL DATE:

“I, Sinem GÜREL, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated in the thesis.”

SİNEM GÜREL

A FUZZY AHP APPROACH FOR FINANCIAL PERFORMANCE EVALUATION OF AIRLINE COMPANIES

Abstract

Previous researches focused on operation performance. This thesis purposes for evaluating the financial performance of the airlines. In order to achieve financial objectives to be incorporated into the financial performance of their degree. It is a method to measure the results of a company's operations in a monetary term. The problem is modeled by multi-criteria decision making (MCDM) one. Multi criteria decision making (MCDM) is a method of the most important fields of operations research and deals with the problems that include multiple and conflicting objectives. It is obvious that when more than objective exists in the problem, making a decision becomes more complex. To solve the problem, I used the fuzzy numbers to explain their values. After that, I used a method of fuzzy multi criteria group decision making (FMCGDM) as Fuzzy Analytic Hierarchy Process (FAHP) to solve the problem of the evaluation of airlines' financial performances. At first time the decision making process of the financial performance is investigated, when financial ratios are given by a fuzzy function, they are obtained through classical methods. After that, we will discuss the main advantages of the new approach. Finally, we illustrate an experimantal model of evaluation of the three domestic airlines' financial performance in Turkey.

Keywords – multi-criteria decision making, fuzzy AHP, aviation sector, financial performance evaluation

HAVAYOLU ŞİRKETLERİNİN FİNANSAL OLARAK DEĞERLENDİRİLMESİ İÇİN BİR BULANIK AHP YAKLAŞIMI

Özet

Önceki araştırmalara bakıldığında havacılık sektöründe operasyon performansına yönelik çalışılmıştır. Bu çalışma, havacılık sektörünün finansal performansı bakımından değerlendirilmesini amaçlamaktadır. Finansal performans şirketlerin finansal faaliyetlerini ifade eder. Finansal performans mali hedeflerin elde edilmiş derecelerini gösterir. Bu firmanın mali dönem içindeki politikaları ve faaliyet sonuçlarını ölçme işlemidir. Problemin uygun görülen çok ölçütlü karar verme tekniklerinden biri ile modemi kurulmuştur. Çok ölçütlü karar verme, yöneylem araştırmasının en önemli alanlarından biridir. Çok ölçütlü karar verme çoklu ve çelişkili problemlerin çözümünde kullanılır. Problemi tanımlarken elimizdeki verilerin yetersizliğinden dolayı bulanık sayıları kullandık. Türkiye'de havacılık sektöründe finansal performans değerlendirmesi yapmak için önerdiğimiz çok ölçütlü karar verme tekniği Bulanık Analitik Hiyerarşi Prosesi (BAHP) idi. Finansal performance değerlemesi yaparken nasıl bir karar verme tekniği uygulanacağı araştırıldı ve problemi çözmek için gerekli finansal oranlar elde edildi. Yeni yaklaşımın sunduğu avantajlar ise tartışıldı. Son olarak Türkiye'de Pazar payı açısından en büyük üç havayolu şirketinin finansal performanslarının değerlendirmesini gösterdik.

Anahtar kelimeler – çok ölçütlü karar verme, bulanık AHP, havacılık sektörü, finansal değerlendirme

Acknowledgements

Before anything else, I want to to thank sincerely my advisor Assoc. Prof. Dr. Zeki AYAĞ. I could be accomplished this thesis with his instruction and guidance. I am grateful him to give me support continuously. Also, I express him sincere thanks for his toleration, motivation, attention, he never denied his extensive knowledge to me, he was always helpful and invaluable assistance for me within this period. My research and writing of this study could not be performed without his guidance. I would like to thank him to give continuous suggestions me. At the same time, I want to thank Prof. Dr. Cengiz KAHRAMAN for his valuable comments.

I owe my family a debt of gratitude for all their love and patience and to encourage and support me. I would like to thank with all my heart my parents A. Kadir GÜREL and Nurten GÜREL for supporting me and their continuous encouragement along my life. Especially, I would like to thank with all my heart my little sister Simge GÜREL for her love, patient, support and encouragement. I thank my big sister N. Özlem GÜREL VAROL for her intencive and support. I thank Turgay ÖZTÜRK, especially, for his percept, contribution and giving encourage. I thank Koray ŞAHİN for his support and continuous encouragement. Finally, I would like to thank my entire family for their continuous encouragement and contribution within this period. Thank you.

To my parents and my sisters

Table of Contents

List of Tables

List of Figures

List of Abbreviations

FAHP: Fuzzy Analytic Hierachy Process

AHP: Analytic Hierachy Process

TFN: Triangular Fuzzy Numbers

MCDM: Multi Criteria Decision Making

MODM: Multi Objective Decision Making

MADM: Multi Attribute Decision Making

MOMP: Multi Objective Mathematical Programming

MOLP: Multi Objective Linear Programming

MAUT: Multi Attribute Utility Theory

SMART: Simple Multi Attribute Rating Technique

ELECTRE: Elimination and Choice Translating Reality English

PROMETHEE: Preference Ranking Organization Method of Enrichment Evaluations

DM: Decision Making

TOPSIS: Technique for Order Preference by Similarity to Ideal Solution

NGM: Normalization of the Geometric Mean

THY: Turkish Airlines

P: Production

M: Marketing

E: Execution

STL: Short term Liquidation

LTS: Long term Solvency

PF: Profitability

DR: Debts Ratio

RI: Return of Investment

AST: Assets and Stockholders' Turnover

CR: Current Ratio

EFR: Equity/Fixed Ratio

ER: Equity Ratio

FLTR: Fixed/Long Term Ratio

DR: Debt Ratio

EDR: Equity/Debt Ratio

OCR: Operation Cost Ratio

GFR: Gross Profit Ratio

OPR: Operation Profit Ratio

IBTR: Income Before Tax Ratio

NIR: Net Income Ratio

CLT: Current Liabilities Turnover

LTLT: Long Term Liabilities Turnover

TLT: Total Liabilities Turnover

IER: Interest Expense Ratio

RCA: Return on Current Assets

RFA: Return on Fixed Assets

RTA: Return on Total Assets

RSE: Return on Stockholders' Equity

ROPC: Return on Operation Profit to Capital

RIBTC: Return on Income Before Tax to Capital

CAT: Current Assets Turnover

FAT: Fixed Assets Turnover

TAT: Total Assets Turnover

SE: Stockholders’ Equity

Chapter 1

Introduction

According to Baron (2000) the strategies and operations of organizations affect their financial performance in market and non-market environments. Financial performance reports provide a financial summary which includes assets, liabilities & capital, and income & expense.

The mean of the word 'performance' is 'to do', to carry out' or 'to render'. It is also related to the execution, achievement, complementation. In broad terms, performance means that the achievement of a job regulated by normals of correctness, exactness, speed, and cost. That is to say, it shows the grade of an accomplishment.

Financial performance performs the financial activity. Financial performance shows the degree of accomplishment of the financial objectives. It is a method to measure the results of a company's operations in a monetary term. To evaluate a business' financial health in a term, this method is used. This method is also used to compare similar firms at the same sector and it is also used to compare industries in accumulation.

Financial analysis involves the utilization of the financial statements. Data collection of accounting procedures organize a financial statement. This means to understand some financial procedures of a business firm. As for a Balance Sheet, it shows an attitude at a moment of time or as for Income Statement, it shows activities of a given period of time.

"Balance sheet is a static picture of the financial situation of a business on a specified date that represents Owner's equity + Total liabilities = Total assets."

The income statement indicates the performance of the financial of a business above a given term of time. "Income statement is a roundup revenues and expenses of a company above a given term, it ends with net income or loss for the period." Therefore, 'financial statements' emphasises two main concepts: the Balance Sheet and the Income Statement. The Balance Sheet represents a business' financial statement in a while of the time. It supplies to take as a static picture.

On the other hand, financial statements don't related with all the instruction the financial functions of a company, but financial statements supply some excessively helpful information, which emphasises two significant elements as profitability and financial stability. Therefore, to analyze of financial statements is an significant step for analysis of financial performance. Financial performance analysis involves to analyze and explain the financial statements as follows this assumes identification of the profitability and financial stability of a company.

"Financial statements analysis is a period of valuating the relation between essentials component of financial statements to attain a better perception the performance and position of the company."

Establishing connections with the elements of the profit, the loss account and the balance sheet analyze the financial performance diagnoses the financial power and financial instability of the business firm. The initial assignment is selection of the information interested in the determination under consideration from the full knowledge involved in the financial statements. The next task is the organization the data in a sense to underline important relations. The last task is the conclusions are explained and drawn. In a word, "analysing of the financial performance is the procedure of choice, valuation, and relation."

Operating performance of a business firm forms financial structure of the firm. It is one of the most important truths about. Also, the financial situation of the firm can decide the operating performance of the firm. Therefore, the financial statements are significant means for the elucidated manager. To evaluate financial performance, financial ratios are used. In management, the financial ratios are used to plan and to evaluate, credit managers and bankers use the financial ratios to estimate, the criticalness of possible borrowers, investors use the financial ratios to evaluate corporate securities, managers use the financial ratios to diagnose and evaluate potential combination candidates.

This thesis includes six chapters. Chapter 2 presents previous studies about fuzzy set theory and Multi Attribute Evaluation Under Fuzziness: Fuzzy Analytic Hierarchy Process (FAHP). In real life the problems are complex, resulting from uncertainess in the parameters that establish the problem. Fuzzy Set Theory displays extensive potential to solve the uncertainty in the problem effectively. The fuzzyness means "vagueness" or "ambiguity" or "uncertainty". Fuzzy Set Theory is a perfect numerical method to overcome doubt in the parameters. Fuzzy sets presented by Lotfi Zadeh (1965). In the literature, there are many fuzzy Analytical Hierarchy Process approaches offered by several authors. Chapter 2 also includes previous studies about Fuzzy Analytic Hierarchy Process (FAHP).

Chapter 3 presents multi criteria decision making (MCDM) and its categories as multi attribute decision making (MADM) and multi objective decision making (MODM). Multi criteria decision making (MCDM) is one of the most significant studies of Operations Research. Multi criteria decision making (MCDM) is a technique to clarify the problem of decision making. It has two categories: multi attribute decision making (MADM) and multi objective decision making (MODM). Multi objective decision making (MODM) models generally deal with continuous problems in which the number of variables is infinite and variables used to define the decision problem tend to be continuous. Models of multi attribute decision making (MADM) try for selection of the best alternative, classify the alternatives from the sublime to the ridiculous or classify them into classes. Among the MADM methods developed in the previous studies, analytical hierarchy process (AHP), multi attribute utility theory (MAUT) and outranking methods are more frequently applied to discrete problems with decision than all other methods. These methods are explained in this chapter.

In this thesis, we make evaluating of the performance of financial of three airline companies in Turkey. These companies are Turkish Airlines, Pegasus Airlines and Onurair. For evaluating financial performance we apply Fuzzy Analytic Hierarchy Process (FAHP) because we got information about financial statements and balance sheet of Turkish Airlines and Pegasus Airlines but we couldn’t get any information about Onurair. Chapter 4 presents an owerviev of Fuzzy Analytic Hierarchy Process (FAHP). I explain a Fuzzy Analytic Hierarchy Process (FAHP) approach that we utilized to solve the problem. I show the equations of FAHP which are used to calculate the problems. Then, evaluation of financial performance is defined. Evaluating the performance of the marketing of airlines, the relationship between the process of input and service must be linked (Zahra, 1995). The relationship between inputs and outputs used by airlines must be understood correctly to evaluate of performance. The last part of Chapter 4 includes performance indicators. Performance indicators are used to evaluate financial performance. In previous studies, the authors applied two basic criteria to select the indicators. The primary criterion is an indicator have to be descriptor. The next criterion is a possible information may be utilized to reason the all of performance evaluation indicators' high correlation. Any is selected as a performance indicator. According to two choice criteria and the ratios of either in the Chapter 4, the group of indicators consists of 25 evaluation. They are classiffied in the three basic classifications as production, marketing, and execution.

Chapter 5 presents a case study that is associated with the evalution of financial performance in Turkish airline companies. First part of Chapter 5 includes an overview of aviation sector in Turkey. In this chapter, we presented the problem's formula and the problem's model. In Chapter 6 we presented the result of this study. I evaluated the financial solutions in this chapter. The solutions are gotten in Chapter 5.

Chapter 2

Literature Review

We investigate the previous studies about fuzzy set theory and Multi Attribute Evaluation Under Fuzziness: Fuzzy Analytic Hierarchy Process in this subject area. This chapter includes previous studies of these concepts.

The primary theory in quantifying uncertainty in scientific models had been probability theory which depends on classical set theory and binary logic. Classical binary logic just allows the opposites of “true” and “false”, which doesn’t allow degrees of truth in between these limits. An item both pertains or does not pertain to the set; the boundary of the set is crisp.

Lotfi Zadeh (1965) introduced fuzzy sets and developed possibility theory. This was an important evolution of the expression of uncertainty. Possibility theory was introduced by Lotfi Zadeh in 1978. D. Dubois and H. Prade further contributed to its development.

The fuzzy set theory is a numerical work structure. It provides to model the doubt or impreciseness of humanistic mental periods which was begun by L. Zadeh. The fuzzy set theory is a fundamental theory of fuzzy limits. The fuzzy logic and the fuzzy set theory were implemented in a wide range of implementation that are researched by various inventors. Fuzzy set theory provides tools to quantify imprecise verbal statements and to classify outcomes of decision-analytical experiments.

Fuzzy set theory has been criticized for being probability theory in disguise; it is easy to understand now that the two theories are concerned with two distinct phenomena:

with observations that can be classified in vaguely described categories only and with experiments such that the outcomes can be classified into well-defined categories. In essence, fuzzy set theory is concerned with our probability to categorize things and to label the categories via natural language.

In a fuzzy set, a member has a grade of membership. This is the fuzzy set theory's main idea. The membership function symbolizes the grade of membership of a member in a fuzzy set. The membership's value of a member are between 1 and 0. Members may refer to both a group in a definite grade and in the multiple set. The fuzzy set permits the fractional members of elements. Changing among memberships and nonmemberships is step by step. Member of function plans overall the variation of value of linguistic variables into several linguistic groups. There are three ways to adapt the membership functions for the linguistic variety for a given case:

1. Authority prior instructions about the linguistic variety,
2. Simple geometric forms are applied, they have slopes as triangular, trapezoidal or s-functions as required the variable's properties and
3. By trial and error learning process.

In the past, there are lots of study about fuzzy AHP that presented by several inventors. The approaches are well-ordered methods to select the best alternative and affirmation problem by use of the conceptions of the analysis of hierarchical structure and the fuzzy set theory. Decision makers generally prefer precise to produce interval judgments to fixed value judgments. As a consequence a decision maker is usually ineffective to be clear about decision maker's choices by way of the vague properties of the matching process.

Van Laarhoven and Pedrycz presented fuzzy AHP initially. This study was comparison of fuzzy ratios that defined by triangular membership functions. Comparison ratios' fuzzy initiatives whose membership functions are trapezoidal is defined by Buckley. Chang (1996) calculated the synthetic extend value of pairwise comparison. To select one criterion over another, triangular fuzzy numbers are utilized in fuzzy AHP method and then Chang's the synthetic extend method is used.

According to Weck et al., (1997), fuzzy AHP approach is one of the best approaches all of different assessment approaches.

Kahraman et al. (1998) obtained the weights through AHP and evaluated the fuzzy weighted by using the methods as a fuzzy objective and subjective. Cheng et al. (1999) presented a new process to evaluate the weapon systems by using of the method of Analytic Hierachy Process which ground on weight of linguistic variety. Zhu et al. (1999) did an argument about applications and approaches of extent analysis of fuzzy AHP. Also, Deng (1999) developed a fuzzy method for solving the multi criteria problems simply. The consistency and ranking problems and helped the definition of the consistency were argued by Leung and Cao (2000). Weck, Klocke, Shell, and Ru¨enauver (1997) applied an approach to assess successfully various alternatives of production cycle. Lee, Pham, and Zhang (1999) applied primacy setting for software development process. Cheng, Yang, and Hwang (1999) evaluated the military systems. Chan, Chan, and Tang (2000) studied on selection of technology. Lee, Lau, Liu, and Tam (2001) presented modular product design and Kwong and Bai (2002) applied the procedure of deployment of the quality function. About food industry, customer satisfaction and food supply chain were studied by Jansen et al. (2001), Creed (2001) and Martinez Tome et al. (2000).

Altinoz (2001) investigated supplier selection in the Textile sector. The concept of business rules in defining selection situations is stressed. The research discoveries are formalized in a broadly structured model that can then be applied to specific supplier selection situations. A structured methodology is developed to analyze selection situations. In order to test the methodology, a software program is developed and applied to an example.

Kahraman, Cebeci & Ulukan (2003) used the fuzzy analytical hierarchy process (FAHP) for selection of the best company as a supplier in the white goods sector in Turkey. They discussed the purchasing directors of a white goods manufacturer. To determine their supplier firms, they took advantage of a questionnaire. The questionnaire provide to determine the main attributes. These attributes are product performances, suppliers and service performances criteria. After the main and subattributes are determined and the hierarchy is structured. Then the selection weights altogether of the main and sub attributions and alternatives are gotten by questionnaires. Firstly, the main attributes are compared according to the basic goal, that is "the chosing the company as a supplier all of the alternatives" by the group of decision making, was made. Then the sub attributes are compared in comparison with main attributes by the group of decision making. After all, the supplier firms are compared according to the subattributes.

The linguistic variety are returned to the triangular fuzzy numbers (TFN) and the pair-wise comparison matrices with TFN's are made. The method of the extent analysis is used to obtain the primacy weight vectors for each of main and sub attributions and alternatives. Finally, the primacy weights whose main and sub attributions and alternates are integrated to define the primacy weight to choose the the best company as a supplier.

Cebeci (2001) and Cebeci and Kahraman (2002) presented a fuzzy AHP (FAHP) approach to assess a catering service company's customer satisfaction.

Kahraman et al. (2004) offered an analytic implementation for selection of the best catering company in Turkey which provides the most customer satisfaction. There are three Turkish catering firms. The best supplier firm was selected as per the most important criteria by using a questionnaire. Regarding the data derived from the questionnaire, the main and sub attributes are selected and the decision hierarchy is structured. The decision making group includes the catering companies' clients and the five authorities of Turkish Chamber of Food Engineers (TCFE). In the second step, the main attributes are matched according to the main goal which is "for chosing the best company as a catering all of the alternates" by the group decision making. In the third step, the sub-attributes are compared in regard to main attributes by the group of decision making (DM). In the fourth step, the catering firms are compared in regard to the sub-attributes by the authorities of Turkish Chamber of Food Engineers. The significations of the main and sub-attributes circumstantiate the clients of the catering companies and the five authorities from TCFE, thus everyone would realize the similar thing when the questionnaire was evaluated by them. To contrast the three catering firms, the fuzzy analytical hierarchy process (FAHP) was applied. The triangular fuzzy numbers' methods obtained by the clients and the authorities for every matching were ably applied in the matrices of pair wise comparison. The linguistic varieties are returned to triangular fuzzy numbers (TFN) and the pair wise matching matrices with TFN's are shaped. To obtain the primacy weight vectors for main and sub attributions and alternates, the extent analysis method is utilized. The first weights of main and sub attributions and alternates are integrated for deciding the primacy weight for chosing the best company as a catering.

Chan and Kumar (2005) invented an approach of the fuzzy extended analytic hierarchy process using the triangular fuzzy numbers (TFN) to show matching decisions of the decision makers and the method of fuzzy synthetic extent analysis to determine the last primacy of various decision criteria. They used this method for selection the best company as a supplier for a manufacturing firm all around the world. A decision making group that comprises the specialist from every strategical area of decision. Through treatment on per criterion, attribution and alternate provider is directed and five criteria are identified. The main criteria which are regarded the chosing of the global are total product cost, service performance of supplier, product's quality, profile of the supplier and the risk factor. After further discussion, nineteen attributions with three suppliers are defined and then the hierarchy with four levels is structured.

Güner (2005) proposed a model to evaluate and select the supplier problem of a marbletravertine company in Denizli. AHP is used in the solution process. So as to solve uncertainty problem and resolve the disadvantageousness of Analytic Hierarchy Process (AHP), linguistic variables and triangular fuzzy numbers (TFN) are applied in pair wise matchings. A supplier selection model is developed for "classical travertine" which is the main product of the company. The criteria and alternatives which used in the evaluation are defined and used fuzzy AHP methods to solve the problem. The results obtained are compared and the same supplier is found to be the optimum alternative. In the second step, fuzzy AHP method with linguistic variables was used to solve a specific supplier selection problem for a customer order. The result is the same as in the first evaluation.

Chen, Feng, and Jiang (2005) offered a overall the approach with regard to fuzzy decision theory and features of the supply chain management for the best integration and to select all of member vendors and outsourced parts. At the beginning step, the decision of process and production capacities eliminate some useless information to select vendor by research capabilities of vendors. Decision of capability is divided into two methods: process decision and capacity decision. The vendors who don't have the capability sufficiency to make the task are filtered in these two steps of decision. In the second section, a hierarchical fuzzy model to select the vendor is structured. Four main criteria are as cost, quality, potential and time and ten subcriteria are used in the selection process. Finally, the coaction all of various order combinations are regarded and the corresponding vendors for these outsourced parts are defined. After deciding the process and capacity of vendors as per the information data, four candidate vendors are chosen for possible strategic cooperation. Finally, the corresponding vendors for four components are defined.

Haq & Kannan (2006) offered a integrated model to evaluate for selection vendor by the analytical hierarchy process (AHP) and fuzzy AHP (FAHP). The main objective is for demonstrating how the model can assist to solve such decisions in practise. The strength of the model of AHP is sampled by use of a firm in the southern part of India and the outcome confirmed by use of fuzzy AHP. In the first step, the hierarchy is structured. It has four levels. The attributes and sub-attributes are selected by conducting a survey on the decision making team which consists of specialist from the industry side. As regards the survey, seven factors are determined as quality, capability of engineering/technical, capability of production, delivery, structure of business, service and price and thirty-two sub-factors. In the second step, the priorities of the elements in each level are determined on the bases of AHP and fuzzy AHP. Finally, the primacy weights for major factors, sub factors and alternatives are integrated to decide the primacy weights of the best vendor. Here, the finding by use of the FAHP method is found to be consistent with the defined the selection of vendor. On the other hand, the weights of three vendors are found to be rather close to each one, from both approaches. Therefore sensitivity analysis should be implemented to define the robustness of such judgements with regard to variations in the pair wise rankings.

Wang et al. (2008) conclude that the method of extent analysis is an approach to present grade of the primacy of a decision criterion or an alternative and which is larger than the another in a fuzzy comparison matrix.

In their research, Tüysüz and Kahraman reviewed numbers of fuzzy AHP approaches. Table 2.1 shows a matching methods of the fuzzy AHP in the past. The methods have significant distinctnesses in their theoretic structures as below. The matching consists of the advantages and disadvantages of every fuzzy AHP approach.

Buyukozkan et al., Kahraman et al., and Ayag and Özdemir used the method of (FAHP) of Chang to solve various decision making (DM) problems in their researches.

By reason of the advantages of the extent analysis of Chang on method of the Fuzzy Analytic Hierarchy Process (FAHP) are comparatively superior to the other methods as the affirmation as in Table 2.1.

Table 2.1 Main Characteristics, Advantages and Disadvantages of AHP

Sources	Main Characteristics	Advantages	Disadvantages
Van Laarhoven Pedrycz (1983)	Direct extension of the AHP method of Saaty with triangular fuzzy numbers. Lootsma's logarithmic least square method is applied to derive fuzzy weights and scores of fuzzy performance.	The considerations of multiple decision makers may be modeled in the reverse matrix.	There is not always a solution to the linear equations. The computational requirement is tremendous, even for a small problem. It allows only triangular fuzzy numbers to be used.
Buckley (1985)	Direct extension of AHP method of Saaty with trapezoidal fuzzy numbers. Applies the geometric mean to derive fuzzy weights and scores of performance.	It is easy to extend the fuzzy case. It guarantees a unique solution to the reverse matching matrix.	The computational requirement is tremendous.
Boender et al. (1989)	Changes method of Van Laarhoven and Pedrycz. Offer a more robust approachment to the normalization of the local priorities.	The considerations of multiple decision maker may be modeled.	The computational requirement is tremendous.
Chang (1996)	Synthetical degree varieties. Layer simple sequencing. Composite total sequencing.	The computational requirement is relatively low. It follows the steps of crisp AHP. It does not involve additional operations.	It allows only triangular fuzzy numbers to be used.
Cheng (1996)	Builds fuzzy standards. Represents performance Scores by membership functions. Uses entropy concepts to calculate aggregate weights.	The computational requirement is not tremendous.	Entropy is used when probability distribution is known. The method is based on both probability and possibility measures.

Chapter 3

Multi Criteria Decision Making

We explain a review of associated with the literature of the multi criteria decision making with the analytic hierarchy process briefly, in this chapter.

3.1 Multi Criteria Decision Making

Decision making (DM) is the selection a route of process from two or more alternatives. It is used to succeed in a particular objective or to find solution of a particular problem.

According to James Stoner, decision making is the method of definition and selection of a route of action for a specific problem's solution.

According to Trewartha and Newport, decision making consists of selecting a route of the action from among two or more probably alternatives in case reach at a solution of a specific problem.

According to Peter Drucker (The Effective Executive), the effective decision does not issue a concurrence according to the facts. This perception underlies the correct decisions grows out of the clash and conflict of different decisions and out of the serious notion of competition alternatives.

According to Pospelov and Pushkin (1972), the correct decision making means to select such an alternative from a probable set of alternatives, by taking notice of all the various factors and opposite requirements, a comprehensive value will be optimized.

According to Harris (1980), decision making is the method to identify and select the alternatives against the decision maker's varieties and choices. Decision making refers that there are alternative selections to be regarded, when this is the case we do not want just the identifying of the alternatives as probable just the selecting of the one that best compliance with the goal, objective, values, desire etc.

Multi criteria decision making (MCDM) is an operation research field which is the most important of them and related with the problems which include multiple and conflicting objectives. It is obvious that when more than objective exists in the problem, making a decision becomes more complex.

In the literature, Roy and Vanderpotten (1996) stated that MCDM methods tries to obtain an ideal solution, derived from a set of processes. MCDM's scope and objective is to provide decision makers during the problem solving to tackle with the decision problems that involve multiple criteria. Different from other simple decision models, MCDM approaches are focused on the development sides of the model which are associated with the modeling and performance of the decision makers' choices, policy of judgment, and values. (Doumpos and Zopounidis, 2002)

According to Chen and Hwang (1991), deterministic methods of MCDM were categorized as regards the variety of the information and the distinct properties of the information by single decision maker. A taxonomy of a number of MCDM methods is given Figure 3.1. For a short statement of the approaches metioned in Figure 3.1 the interested reader may want toconsult with (Hwang, 1987) or (Chen and Hwang, 1991). It should be represented which there are various alternative aspects to classify methods of MCDM. (Chen and Hwang, 1991)

Zimmermann (1994) categorized the MCDM in two classes as the following;

a) Multi objective decision making (MODM) and
b) Multi attribute decision making (MADM).

Some researchers (Doumpos and Zopounidis, 2002) performed this classification based on the problem type: discrete or continuous. Doumpos and Zopounidis (2002) graphically represented the discrete and continuous problems which are dealt with MADM and MODM methods.

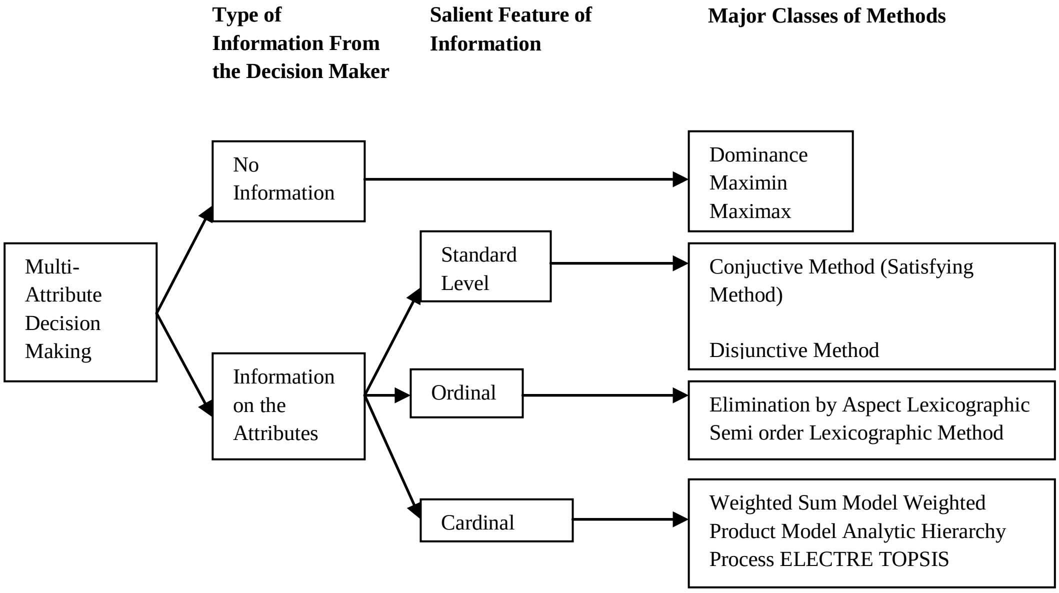


Figure 3.1 A Taxonomy of MCDM Methods (according to Chen and Hwang, 1991)

3.1.1 Multi-objective decision making (MODM)

MODM models usually deal with continuous problems in which the number of variables is infinite and variables used to determine the decision problem tend to be continuous. Most of MODM methods are based on mathematical programming in which there are more than one objective to be optimized and try to obtain an appropriate compromise solution form a set of efficient solution (also called as nondominated or pareto optimal solutions). In general, a multi objective mathematical programming (MOMP) model can be formulated as:

$$\begin{cases} Max\ (or\ Min)\{f_1(x), f_2(x), \dots, f_k(x)\} \\ Subject\ to: g_i(x) \ \leq b_j \end{cases} \qquad (3.1)$$

In formulation 3.1, x represents the decision variables' vector, $\{f_1(x), f_2(x), \dots, f_k(x)\}$ represent the objective functions to be maximized (or minimized), $g_i(x) \ \leq b_j$ is a set of constraints. If the objective functions and constraints are formulated linearly, then MOMP model becomes a multi-objective linear programming (MOLP). Most of the MOMP models in the literature are formulated as a MOLP and several methodologies have been developed to solve these models such as STEM (Benayoun et al., 2001) and Zionts and Wallenious

(1976)'s interactive approach. GP is the one of the most powerful and well known MOMP solution methodology. Up to date several variants of GP have been proposed to address MODM problems.

3.1.2 Multi-attribute decision making (MADM)

In MADM, each alternative is defined by using multiple attributes. For a given set of alternatives, MADM models try to select the optimum alternative all of them, rate the alternatives from the best to the worst or classify them into classes. Although the MADM methods are usually used to solve discrete problems, some of them can also applied inside of the content of permanent decision problems. (Doumpos and Zopounidis, 2002)

3.2 Multi attribute decision making methods

All of the methods of multi attribute decision making (MADM) developed at the previous studies, analytical hierarchy process (AHP), multi attribute utility theory (MAUT) and outranking methods are more often used to discontinous judgement problems than among other approaches. The following sub-sections give a summary introduction to the base notion and properties of them.

3.2.1 Analytic Hierarchy Process (AHP)

Analytic Hierarchy Process (AHP) is the combination of the analysis of multi objective decision and the analysing of qualitative with quantitative. AHP is offered by Thomas L. Saaty and applied in the key decision model. The main rule is to employe the structure with hierarchial which includes goal and sub goals and the circumstance of the constraint for evaluation of the stage of the study.

The AHP method takes complete aggregation all of criteria and it improves a linear additive model. Due to pairwise comparisons between each one of all choices, the weights and scores are obtained essentially. (ODPM, 2004)

According to Salo and Hämäläinen (1997), AHP is a very successful method to obtain the acceptance of implementers, represents the hierarchical problem and the appeal of pairwise comparisons. According to Vargas (1990), the distance of stated practical implementations is comprehensive and involves Resource Allocation, Strategic Planning and Project/Risk Management. Ramanthan et al. (2001) offered the model of the AHP to appeal the requirement in the face of multiple criteria and multiple stakeholders in Environmental Impact Assessment (EIA).

Gomez−Limon and Atance (2004) presented the AHP method to expose the choices that citizens allocate to the several probable objectives of the European Common Agricultural Policy (CAP). This approach is methodological which has been applied all of citizens of Castilla y León (Spain).

T. L. Saaty (1977) improved the Analytic Hierarchy Process (AHP) as an approach of multi criteria decision making (MCDM). This approach can be seperated from a multi-objective problem to single objective problems. It has a structure as hierarchical which includes goals and sub goals and the constraints. There are four steps of AHP:

1. Building a hierarchy

At the beginning, the problem is determined and to decompose it from top to bottom in a diagram. The diagram includes the goal which is up the hill, the criteria and the alternatives which are at the bottom. Figure 3.2 illustrates a typical hierarchy of AHP.

In Figure 3.3, there is a three levels hierarchy with three criteria and each criterion has the four alternatives. The structure can have infinite number of levels.

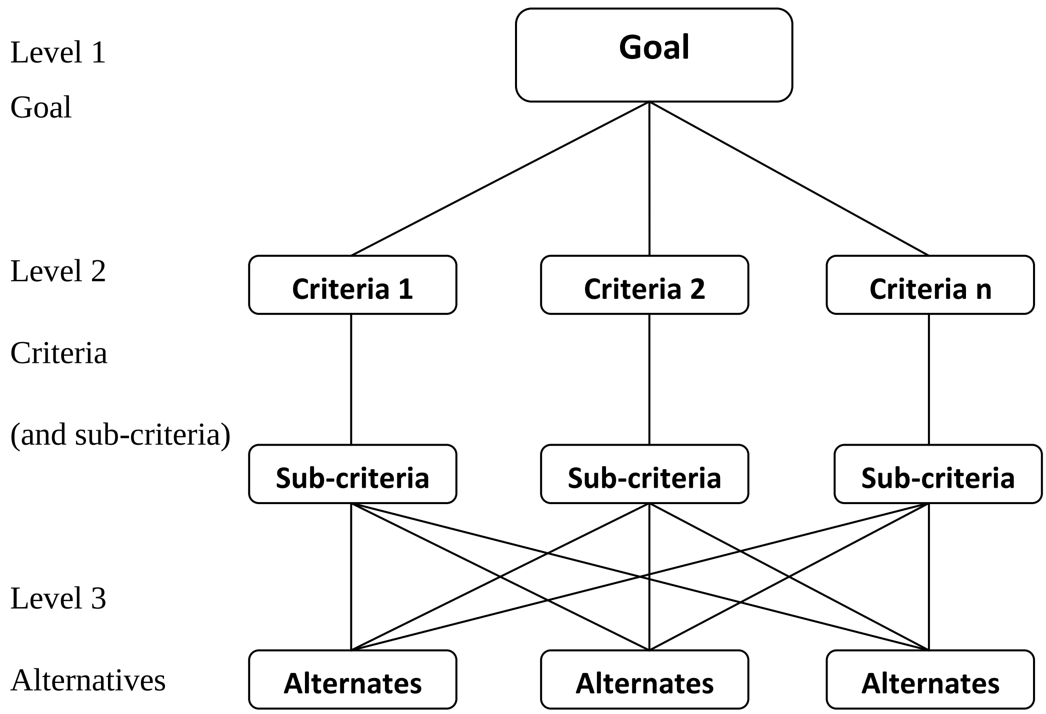


Figure 3.2 A typical hierarchy of AHP

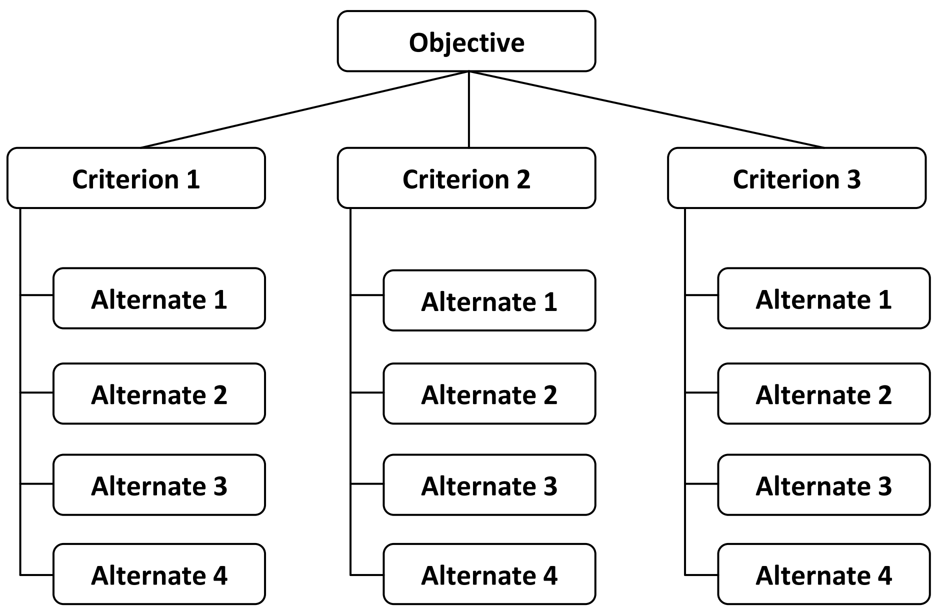


Figure 3.3 A three levels hierarchy with three criteria and four alternatives

2. Pair-wise comparisons

The second step is to get input data according to decision elements' pair wise comparisons and the comparison of the each criteria two by two according to the level right above them. This can be expressed mathematically by a reciprocal square matrix that results from the weight ratios (n x n), n bwing the number of compared elements. Table 3.1 shows an example of criteria pair wise comparison matrix.

Table 3.1 Criteria pair wise comparison matrix

Objective	**Criterion 1**	**Criterion 2**	**Criterion 3**
Criterion 1	1	a	b
Criterion 2	1/a	1	b/a
Criterion 3	1/b	a/b	1

After that, the alternatives are compared with respect to every criterion. This results in as many matrices as there are criteria, each one corresponding to a criterion.

Table 3.2 Alternatives pair-wise comparisons matrix

Criterion 1	**Alternate 1**	**Alternate 2**	**Alternate 3**	**Alternate 4**
Alternate 1	1	İ	j	k
Alternate 2	1/i	1	j/i	k/i
Alternate 3	1/j	i/j	1	k/j
Alternate 4	1/k	i/k	j/k	1

Table 3.2 shows the comparison matrix which includes alternatives in regard to one criterion.

Table 3.3 The scale of absolute numbers

Numeric scale	**Verbal scale**
1	The two members contribute equally to the objective
3	One element contributes slightly more than the other
5	One element contributes more than the other
7	One element contributes much more than the other
9	One element contributes extremely more than the other
2, 4, 6, 8	Intermediate values for more precision

The variables in Table 3.1 and 3.2 (a, b, i, j and k) take the numerical values that are defined in Table 3.3.

3. Determination of priorities

The next step is to calculate the relevant consideration of every element in the hierarchy. This will be done by solving the matrix in equation (3.2). We suppose that n criteria is given as $A_1, ..., A_n$, with the weights as $w_1, ..., w_n$, and assume that a pair-wise matrix of ratios is developed with rows that provide the ratios of the weights of every criterion according to all others, and then the equation is obtained as Aw = nw. A consists of the multiplying by the weight w's vector. The conclusion of this, nw is obtained:

$$\begin{pmatrix} \frac{w_1}{w_1} & \frac{w_1}{w_2} & \cdots & \frac{w_1}{w_n} \\ \vdots & & \ddots & \vdots \\ \frac{w_n}{w_1} & \frac{w_n}{w_2} & \cdots & \frac{w_n}{w_n} \end{pmatrix} \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{pmatrix} = n \begin{pmatrix} w_1 \\ w_2 \\ \vdots \\ w_n \end{pmatrix} \qquad (3.2)$$

A has unit rate as from each row is a fixed multiplying of the first row. Therefore except one of eigenvalues are zero. The total of the eigenvalues which are in a matrix is even its mark, the amount of its diagonal components, then the mark of A is even

n. Therefore n occurs an eigenvalue of A, and one has a nontrivial solution. The solution includes positive inputs and it is single inclusive of a multiplicative constant. One may standardize its inputs by dividing by sum of them to perform w unique. Accordingly, the comparison matrix that is given, one can get the scale. It means that, the result is any normalized column of A.

In the overall case, the accurate rate of w_i/w_j may not be specified, but alternatively only an forecast of it as an assesstment. For the present, regard an forecast of these rates by an specialist who is supposed to perform small concerns of the factors. This refers small concerns of the eigenvalues. Now, the problem turns as $A'w' = \lambda_{max}w'$. λ_{max} shows the largest attribute of A'. To reduce the formula, we should go on as $Aw = \lambda_{max}w$. A represents the matrix of pair wise comparisons. Now, problem occurs how well is the forecast of w. If w is gotten by use of reason of the problem, the matrix whose inputs are as w_i/w_j is a stabilized matrix. It turns out that A is stabilized if and only if $\lambda_{max} = n$ and that we have $\lambda_{max} \geq n$. When the extents do not subsist and assesstments are utilized, the matrix gets the form of positive reverse:

$$A = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix} \qquad (3.3)$$

Even though reverse in $a_{ji} = 1/a_{ij}$, the matrix does not require to be stabilized. Generally, expert opinions are performed to forecast the ratios of the inputs in the vector w.

4. Synthesis and coherence assessment

Once the local priorities for each level in the hierarchy are determined, the next step is to assess the coherence of the expert judgments. The overall inconsistency of the judgments should not be more than 10%. An approximation of inconsistency is provided by a Consistency Index (CI) defined by Saaty:

$$CI = \frac{\lambda_{max} - n}{n - 1} \qquad (3.4)$$

Finally, the synthesis is carried out by matrix resolution.

3.2.2 Multi attribute utility theory (MAUT)

MAUT is a range of benefit theory that allows the preferences to be represented in terms of value functions $G(h)$, where h is the vector of the valuation criteria $h=(h_1,h_2,..,h_n)$. The MAUT based models integrate multiple marginal value functions into an aggregated utility function to be maximized. Commonly, marginal utility functions are aggregated into an additive fashion (Doumpos and Zopounidis, 2002):

$$G(h) = w_1 g_1(h_1) + w_2 g_2(h_2) + \dots + w_n g_n(h_n) \qquad (3.5)$$

Every marginal benefit function $g_i(h_i)$ determines the benefit of the alternatives for every individual criterion h_i. Weights w_i represents the consistent significance of criterion i. The benefit function can be defined as linear or non-linear. Simple multi attribute rating technique (SMART) is the easiest model of MAUT in which marginal utility functions are defined linearly and utility of an alternative is simply obtained as weighted average of marginal utility values. We refer the interested reader Keeney and Raiffa's (1993) book for a detailed explanation.

3.2.3 Outranking methods

Outranking methods try to find a binary relation between alternatives to show an alternative is preferred ("outranks") to another one. The main rule of outrank is that alternative x would be favored upon y if x is preferable to y on the generality of criteria. There is no criteria in fact y is preferably as regards x strongly. (Le Teno & Mareschal, 1998).

According to De Boer et al., (1998) and Dulmin & Mininno, (2003) the partial compensation and incomparability are the distinctive features of outranking methods. In contrast to traditional linear weighting techniques, outranking methods are just relatively compensatory (De Boer et al., 1998; Dulmin & Mininno, 2003). If the decision maker may not offer alternate x is better than alternate y or rather, the outrank methods permit definitively for uniqueness (Geldermann et al., 2000).

The more commonly used outranking methods are ELECTRE and PROMETHEE. There are several variants of both methods. The methods and their variants will be explained in the following sub-sections.

ELECTRE (Elimination and Choice Translating Reality English) type techniques are the furthest recognised outranking methods and they were ably implemented to a large variety of areas. There are several versions of ELECTRE approaches consist in literature, like ELECTRE I, ELECTRE II, ELECTRE III, ELECTRE IV and TRI. Although all of them have same fundamental concepts, they were developed and used for different types of decision problems. ELECTRE I (Roy, 1968) was developed for selection purposes. ELECTRE II, III and IV (Roy 1991) were proposed to array the alternatives from the best to the worst. Finally, ELECTRE TRI (Yu, 1992) was proposed based on the ELECTRE III framework to be interested in the classification problems. Since this dissertation focuses on the sorting problematic, more pages will be devoted to in explaining ELECTRE TRI in the later sections. However, in this section, ELECTRE III, which is the base of ELECTRE TRI, will be briefly explained. A detailed description of ELECTRE methods and applications can be found in the works of Figueira J., Greco et al. (2004), Georgopoulou et al. (1997), Rogers and Bruen (2000) and Karagiannidis and Moussiopoulos (1997).

Relationships between thresholds and outranking are two significant notions in ELECTRE approach. Suppose that H shows criteria's set such as h_j, j=1,2,…,r and A is alternatives' set. If the performance alternative x and alternative y are determined by functions as regards the *jth* criterion like $h_j(a)$ and $h_j(b)$, the preference relations all of alternatives may be determined by applying the notions of indifference (q) and preference (p) limits as the following (Roy, 1991)

xPy (x is strongly favourite to y) if $h_j(x) - h_j(y) \geq p_j$
xQy (x is weakly favourite to y) if $q_j < h_j(x) - h_j(y) < p_j$
xIy (x is indifferent to y) if $h_j(x) – h_j(y) \leq q_j$ (3.6)

The ELECTRE approaches prove to get an outranking relationship xSy which is "x is at the least almost y". In ELECTRE III, there are two significant rules as concordance and discordance which are utilized to approve the contention *xSy*. The j^{th} criterion is in concordance with the argument *xSy if* $h_j(y) - h_j(x) \leq q_j$. However, the j^{th} criterion is in discordance with the argument *xSy* if $h_j(y) - h_j(x) \leq p_j$. The concordance index *C(x,y)* may be determined such as in Eq. 3.7 to evaluate the strength as *aSb*. (Hokkanen and Salminen, 1997)

$$C(x,y) = \frac{1}{K} \sum_{j=1}^{m} k_j \; c_j \; (x, y) \; where \; K = \sum_{j=1}^{m} k_j \qquad (3.7)$$

where k_j represents the criterion *j*'s weight, and the concordance grade $c_j(x,y)$ shows the grade of the assertion alternative *x* is at any rate almost alternative *y* in the way of criterion *j*. The concordance rank $c_j(x,y)$ may be assessed as the following:

c_j (x,y) = 0 if h_j (y) - h_j (x) > p_j

c_j (x,y) = 1 if h_j (y) - h_j (x) > q_j

$$c_j\ (x,y) = \Theta \quad if\ in\ between\ and\ \Theta = \frac{p_j + h_j\ (x) - h_j\ (y)}{p_j - h_j} \qquad (3.8)$$

Calculation of index of the discordance needs an further threshold value named as 'veto'. *v* represents the veto threshold, permits to reject argument *xSy* if $h_j(y) \geq h_j(x) + v_j$. The discordance index for every criterion *j*, $d_j(x,y)$ may be defined as in Eq. 3.9.

d_j (x,y) = 0 if h_j (y) - h_j (x) ≤ p_j

d_j (x,y) = 1 if h_j (y) - h_j (x) > v_j

$$d_j\ (x,y) = \gamma \quad if\ in\ between\ and\ \gamma = \frac{p_j + h_j\ (x) - h_j\ (y)}{v_j - h_j} \qquad (3.9)$$

For every criterion, a discordance matrix is generated. Different from concordance, a discordant criterion is sufficient to reject outranking relations. Finally, the grade of outranking is determined by *S*(*x*,*y*) and may be obtained from Equation 3.10. (Salminen and Hokkanen, 1997)

$$S(x,y) = c(x,y) \qquad if\ d_j(x,y) \leq c(x,y)\ \forall j \in J$$

$$S(x,y) = c(x,y)* \prod_{j \in J(x,y)} \frac{1 - d_j(x,y)}{1 - c(x,y)} \qquad otherwise$$

where J(x,y) is the set of criteria for which d_j (x,y) > c(x,y) (3.10)

A distillation process is applied, to get the final ranking. It offers two preorders, ascending and descending. First of all, the order of rank begins from the best graded alternate, secondly, the organization of rank begins from the worst graded alternate. The last partial ordering of the alternates may be procured relying on two preorders. (Hokkanen and Salminen, 1997)

The improvements of the PROMETHEE (Preference Ranking Organization Method of Enrichment Evaluations) approaches started by Vicke and Brans (1985) and Brans et al., (1986) on the PROMETHEE I and PROMETHEE II approaches. PROMETHEE is a ordering approach rather basic in introduction and practise matched to other approaches to analyze of multicriteria. (Goumas and Lygreou, 2003)

The PROMETHEE technique guides to the improvement of an outranking techniques relation which can be utilized both the selection of the optimum alternates (PROMETHEE I) and to grade the alternates from the most favourite to the least favored (PROMETHEE II). The process of the valuation, specified set of alternates A, in PROMETHEE includes pair wise comparisons (a_j, a_k) to define the favourite index $\pi(a_j, a_k)$ evaluating the grade of favourite for a_j over a_k, as the following in Equation 3.11:

$$\pi(a_i, a_k) = \sum_{i=1}^{n} w_i P_i\left(h_{ji} - h_{ki}\right) \in [0,1] \qquad (3.11)$$

The preferred array is same to the universal concordance array of the ELECTRE approaches. The superior the preferred array, the superior the power of the preferred for a_j above a_k. The total of the preferred array rely on the criteria weights' identification w_i $(\sum w_i = 1, w_i \geq 0)$ and the preferred function P_i for every criterion h_i. The preferred function occurs growing function of the difference between the performances (h_{ji} - h_{ki}) of a_j and a_k on h_i. The function is standardized between 0 and 1. The $P_i(a_j, a_k) \approx 1$ argues a powerful choice for a_j above a_k with respect to the h_i, as $P_i(a_j, a_k) \approx 0$ specifies powerless choice. In general, the preferred functions can have several ways, relaying on the opinion procedure of the decision making (DM). Brans and Vincke (1985) offered six especial ways that appear enough in applying. The conclusions of the matchings did for the total couples of the alternatives (a_j, a_k) are regularized in a significance outrank graphic. The nodes of the graphic show the alternatives, there are the arcs between the nodes a_j and a_k, they show the selection of alternate a_j over a_k (if the arc's direction is $a_j \rightarrow a_k$) or the reverse (if arc's direction is $a_k \rightarrow a_j$). Every arc related to a way refering the choice array $\pi(a_j, a_k)$. The amount of all these ways excursion a node a_j is also titled as the leaving flow $\phi^+(a_j)$. The leaving flow offers an evaluation of the outranked character of the alternative a_j over whole alternatives which in A. In a same method, the total of the flows inserting a node a_j is also titled as the entering flow $\phi^-(a_j)$. The entering flow evaluates the outranking character of the alternate a_j matched to all alternates which in A.

For the selection of the optimum alternative (PROMETHEE I is used) or to array the all alternates from the most favored to the minimum one (PROMETHEE II is used), the heuristic principles of PROMETHEE I and II are applied. PROMETHEE I includes the description of the preference (P), indifference (I) and incomparability (R) and their relationships of the main of the leaving flows and entering flows of the outranked graphic. (Vincke and Brans, in 1985)

In PROMETHEE II approach, the classifying of the alternates is attributed the difference between the leaving flow and the entering flow as $\phi(a_j) = \phi^+(a_j) - \phi^-(a_j)$., which procures the net flow, for alternative a_j . The aggregate valuation array of the performance and classifying of the alternates are created by the net flow. The alternates with the higher net flows are regarded as the most favourite one, as the least choiced alternates are the one with the lower net flows.

A well-known MCDM method is TOPSIS which applied to make a decision matrix to assist ease and finish the selection process. This paper also includes which modified by the authors TOPSIS approach for decision making group. TOPSIS is a largely approved a technique of multi-attribute decision-making based on logic, synchronical allowance of the ideal solution and the nonideal solution, and principle of simply programable calculation. TOPSIS needs quantitative characters denoted as crisp numbers, even though it has limitless advantages. A basic feasible decision-making (DM) algorithm, which can manage fuzzy and crisp data denoted triangular fuzzy numbers and in linguistic terms, is offered.

Yoon and Hwang (1980) presented TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) and uses the main approaches of ELECTRE process. TOPSIS depends on decision points' nearness to ideal solution main principal and solution process shorter than ELECTRE method. This technique regards three types of criteria (or attributes) such as quantitative benefit attributes, qualitative benefit attribute/criteria, cost attribute or criterion.

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) regards the extents either the solutions as the ideal and the negative ideal concurrently by describing ‘‘relative closeness to ideal solution”, C_i^* as regards the relation:

$$C_i^* = \frac{S_i^-}{S_i^- + S_i^+} \qquad (3.12)$$

Where S_i^- is the excursion from the solution of negative ideal regulated by the n-dimensional Euclidean extent between the ith alternate and the solution of negative ideal. Where S_i^+ is the excursion from the ideal solution regulated by the n-dimensional Euclidean range between the i^{th} alternate and the ideal solution.

There are six steps of TOPSIS method:

Step 1: Compute the normalized the decision matrix $T=[t_{ij}]_{mxn}$. The value, which is normalized, t_{ij} is computed as

$$t_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \qquad j=1, 2, \ldots,n;\ i=1, 2, \ldots, m \qquad (3.13)$$

The normalization is done for convenience of comparison by converting different units of attributes to a unified unit.

Step 2: Calculate the weighted standardized the decision matrix $Z=[z_{ij}]_{mxn}$. The value of the weighted standardized z_{ij} is obtained from

$$z_{ij} = (r_{ij})(w_j) \qquad j=1, 2, \dots, n;\ i=1, 2, \dots, m \quad (3.14)$$

w_j shows the weight of the j^{th} and $\sum_{j=1}^{n} w_j = 1$

Step 3: Define the positive ideal solution (PIS) X^+ and the negative ideal solution (NIS) X^- as

$$X^+ = \{(\max_i z_{ij} \mid j \in J), (\min_i z_{ij} \mid j \in J'), i = 1, 2, \dots, m\} = \{z_1^+, z_2^+, \dots, z_n^+\}$$
$$X^- = \{(\min_i z_{ij} \mid j \in J), (\max_i z_{ij} \mid j \in J'), i = 1, 2, \dots, m\} = \{z_1^-, z_2^-, \dots, z_n^-\} \quad (3.15)$$

J represents a set of benefit attribute, J' represents a set of cost attribute.

Step 4: Assess the excursion measurements, by use of the distance of the *n*-dimensional Euclidean. The excursion of every alternate from the positive ideal solution (PIS)

$$S_i^+ = \sqrt{\sum_{j=1}^{n} \left(z_{ij} - z_j^+\right)^2} \qquad i = 1, 2, \dots, n \qquad (3.16)$$

The excursion of every alternate from the negative ideal solution (NIS)

$$S_i^- = \sqrt{\sum_{j=1}^{n} \left(z_{ij} - z_j^-\right)^2} \qquad i = 1, 2, \dots, n \qquad (3.17)$$

Step 5: Calculate the relation proximity to the ideal solution.

$$C_i^* = \frac{S_i^-}{S_i^- + S_i^+} \quad i = 1, 2, \dots, m;\ 0 \le C_i^* \le 1 \qquad (3.18)$$

In here; C_i^* takes a value between $0 \le C_i^* \le 1$ intervals and $C_i^* = 1$ shows the absolute closeness of related decision point to the ideal solution, $C_i^* = 1$ shows the absolute proximity of related decision point to the negative ideal solution (NIS).

Step 6: Classify the alternatives with respect to C_i in the decreasing order. The preferred alternate is the proximate interval from the positive ideal solution and the most distant interval from the negative ideal solution (NIS), where a higher C_i means higher choice.

Chapter 4
Proposed Approach

4.1 Fuzzy Analytic Hierarchy Process (FAHP): Overview And Background

Usual approaches of AHP can be of no use when uncertainness is presented in data of the problems. For the first time presented and practiced fuzzy sets theory by Zadeh (1965). Van Laarhoven and Pedrycz (1983) offered the oldest method in fuzzy AHP. At this work, triangular membership functions define the fuzzy ratios. They offered an algorithm and this algorithm is the immediate range of AHP method of Saaty. In that algorithm, triangular fuzzy numbers are utilized.

Van Laarhoven and Pedrycz's model as follows:

Minimize

$$\sum_{i<j}\sum_{k=1}^{\delta_{ij}}\left(\ln w_i - \ln w_j - \ln a_{ijk}\right)^2 \qquad (4.1)$$

Subject to

$$l_i\left(\sum_{j=1,j\neq i}^{n}\delta_{ij}\right) - \sum_{j=1,j\neq i}^{n}\delta_{ij}\,u_j = \sum_{j=1,j\neq i}^{n}\sum_{k=1}^{\delta_{ij}} l_{ijk}, \qquad i = 1,2,\ldots,n \quad (4.2)$$

$$m_i\left(\sum_{j=1,j\neq i}^{n}\delta_{ij}\right) - \sum_{j=1,j\neq i}^{n}\delta_{ij}\,m_j = \sum_{j=1,j\neq i}^{n}\sum_{k=1}^{\delta_{ij}} m_{ijk}, \qquad i = 1,2,\ldots,n \quad (4.3)$$

$$u_i \left(\sum_{j=1, j\neq i}^{n} \delta_{ij} \right) - \sum_{j=1, j\neq i}^{n} \delta_{ij}\, l_j = \sum_{j=1, j\neq i}^{n} \sum_{k=1}^{\delta_{ij}} u_{ijk}, \qquad i = 1, 2, \ldots, n \quad (4.4)$$

where a_{ijk} (k =1, 2, …, δ_{ij}) are δ_{ij} estimates for w_i/w_j (δ_{ij} may equal to zero, if there is no comparing; it equals to or bigger than one, in that case there are a few comparing) and l_{ijk}, m_{ijk} , and u_{ijk} are modal, lower and upper varieties of

$$\ln a_{ijk} = -\ln a_{jik},$$

respectively.

Buckley et al. (1985) applied the method of the Normalization of the Geometric Mean (NGM). They used this method to calculate the weights from the fuzzy pair-wise comparison matrices from this formula

$$w_i = \frac{a_i}{\sum_{i=1}^{n} a_i} \qquad (4.5)$$

where

$$a_i = \left(\prod_{j=1}^{n} a_{ij} \right)^{1/n} \qquad (4.6)$$

a_i represents the geometric mean of criterion i. a_{ij} represents the comparing variety of criterion i to criterion j. w_i represents the weight of i^{th} criterion, where w_i > 0 and $\sum_{i=1}^{n} w_i$ = 1.

To evaluate in the group, it is needed to overall evaluator's judgments into one. Consideration of the valuation given by the specialist $E_i = (a_L^{(i)}, a_M^{(i)}, a_U^{(i)})$ the overall specialist's opinions can be calculated by use of average means

$$\tilde{A} = \left(\frac{1}{n} \sum_{i=1}^{n} a_L^{(i)}, \frac{1}{n} \sum_{i=1}^{n} a_M^{(i)}, \frac{1}{n} \sum_{i=1}^{n} a_U^{(i)} \right) \quad (4.7)$$

The last weight vector is produced by defuzzyfying the average

$$w_{(i)} = \left(\frac{\frac{1}{n}\sum_{i=1}^{n} a_L^{(i)}, 2\left\{\frac{1}{n}\sum_{i=1}^{n} a_M^{(i)}\right\}, \frac{1}{n}\sum_{i=1}^{n} a_U^{(i)}}{4} \right) \quad (4.8)$$

The weight of i[th] sub criteria under k[th] main criteria is gotten by use of (w_k x s_{ki}) where w_k is the k[th] main criteria weight and S_{ki} shows the weight of i[th] sub-criteria in terms of k[th] main criteria.

Once the weight of criteria and sub criteria is calculated and is multiplied by use of Equation 4.9 to get global weighst of sub criteria, it is needed to compute the aggregate score of all alternatives for their valuation. The all score of m[th] alternative is gotten by

$$A_m = \sum_{l=1}^{N} S_l \times a_{ml} \quad (4.9)$$

S_l represents the weight of l[th] sub criteria and a_{ml} represents the weight of m[th] alternative in terms of l[th] sub criteria.

Boender et al. (1989) improved the method of Van Laarhoven and Pedrycz as follows:

Minimize

$$\sum_{i=1}^{m} \sum_{j=i+1}^{m} \sum_{k \in D_{ij}} \{\ln(w_{ijkl}) - \ln(a_{il}) + \ln(a_{ju})\}^2 + \{\ln(w_{ijkm}) - \ln(a_{im}) + \ln(a_{jm})\}^2 + \{\ln(w_{ijku}) - \ln(a_{iu}) + \ln(a_{jl})\}^2 \quad (4.10)$$

Subject to

$$\ln(a_{il})\sum_{j\neq i}^{m}\delta_{ij} - \sum_{j\neq i}^{m}\delta_{ij}\ \ln(a_{ju}) = \sum_{j\neq i}^{m}\sum_{k\in D_{ij}}\ln(w_{ijkl}), \qquad i = 1, 2, \dots, m \quad (4.11)$$

$$\ln(a_{im})\sum_{j\neq i}^{m}\delta_{ij} - \sum_{j\neq i}^{m}\delta_{ij}\ \ln(a_{jm}) = \sum_{j\neq i}^{m}\sum_{k\in D_{ij}}\ln(w_{ijkm}), i = 1, 2, \dots, m \quad (4.12)$$

$$\ln(a_{iu})\sum_{j\neq i}^{m}\delta_{ij} - \sum_{j\neq i}^{m}\delta_{ij}\ \ln(a_{jl}) = \sum_{j\neq i}^{m}\sum_{k\in D_{ij}}\ln(w_{ijku}), \qquad i = 1, 2, \dots, m \quad (4.13)$$

where w_{ijkl}, w_{ijkm}, w_{ijku} are obtained from lower, modal, and upper primacy vectors, separately. Fuzzy ratings $\tilde{a}_{ij}$ are offered by $\ln(a_{il})$, $\ln(a_{im})$, $\ln(a_{iu})$, $\ln(a_{jl})$, $\ln(a_{jm})$ and $\ln(a_{ju})$.

Although AHP is a popularity method, this method may not be an adequate about decision making (DM). A fuzzy AHP (FAHP) approach can countanance uncertainty or ambiguity, since fuzziness and uncertainness are mutual attributes in such problems of decision making (DM). (Mikhailov and Tsvetinov, 2004)

According to Erensal et al. (2006) AHP approach cannot entirely represent a type of human notions because the decision makers often sense more assured to provide distance opinions preferably phrasing their opinions in the way that single numeric values. So that FAHP is talented of interception an evaluation of human evaluation of vagueness when complex problems of multi-attribute decision making are regarded.

Zadeh (1965) produced his work Fuzzy Sets. At this work the mathematics of fuzzy set theory is defined. This theory offered to make the membership function (F and T) manage above the distance of actual numbers as [0, 1]. The basic attribute of the uncertainness is the group of particular in categorizes which do not have stingingly described bounds (Hansen, 2005). The fuzzy number may offer the indefinite comparing decision. Three real numbers describe a triangular fuzzy number which is the essential order of fuzzy number of member, reflected like (l, m, u).

$$(x) = \begin{cases} -x, & x < 0 \\ x, & x \geq 0 \end{cases} \qquad (4.14)$$

$$\mu_A(X) = \begin{cases} (x-l)/(m-l), & l \leq x \leq m \\ (u-x)/(u-m), & m \leq x \leq u \\ 0 & x < l,\ x > u \end{cases} \qquad (4.15)$$

Assume that X = {x_1, x_2, …, x_n} is a set of object, and U = {u_1, u_2, …, u_n} is a set of goal. As regards the extent analysis method of Chang (1992), every objective is gotten and extent analysis for every goal as g_i; is executed. Thusly, m extent analysis varieties for every goal may be gotten, hereinbelow:

$$M_{g_i}^1, M_{g_i}^2, \dots, M_{g_i}^m, \qquad i = 1, 2, \dots, n \qquad (4.16)$$

$M_{g_i}^j = (1, 2, \dots, m)$ show triangular fuzzy numbers(TFNs).

There are three items of the method of extent analysis of Chang below;

Step 1: Determine the fuzzy synthetic extent' values in terms of the i^{th} object by use of the standard fuzzy arithmetic as follow:

$$S_i = \sum_{j=1}^{m} M_{g_i}^j \times \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j \right]^{-1} \qquad (4.17)$$

Where x shows the expanded multiplying of two fuzzy numbers. $M_{g_i}^j$ denotes a triangular fuzzy number which represent the significance ratio among i and j in comparing with the goal k.

$M_{g_i}^j$ represents the comprehensive member of a fuzzy pair-wise comparison matrix and S_i denotes the i^{th} stock's performance in comparing to the k^{th} goal, which equals to the FAHP.

To get $\sum_{j=1}^{m} M_{g_i}^{j}$, carry out the process of the m extent analysis' fuzzy addition varieties for a specific matrix like

$$\sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{j=1}^{m} l_j , \sum_{j=1}^{m} m_j , \sum_{j=1}^{m} u_j \right) \quad (4.18)$$

and to get $[\sum_{j=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j}]^{-1}$ carry out the operation of fuzzy addition of $M_{g_i}^{j} = (1, 2, \ldots, m)$ values as

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{i=1}^{n} l_i , \sum_{i=1}^{n} m_i , \sum_{i=1}^{n} u_i \right) \quad (4.19)$$

then calculate the reverse of vector in Equation 4.20 in fact

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i} \right) \quad (4.20)$$

Step 2: The rank of probability of $M_2 = (l_2, m_2, u_2) \geq M_1 = (l_1, m_1, u_1)$ is described as

$$V (M_2 \geq M_1) = sup_{y \geq x} = \left\lfloor min\left(\mu_{M_1}(x), \mu_{M_2}(y) \right) \right\rfloor \quad (4.21)$$

$$V (M_2 \geq M_1) = hgt (M_1 \cap M_2) = \mu_{M_2}(d) = \begin{cases} 1, & if\ m_2 \geq m_1 \\ 0, & if\ l_1 \geq u_2 \\ \frac{(l_1 - u_2)}{(m_2 - u_2) - (m_1 - l_1)}, & otherwise \end{cases} \quad (4.22)$$

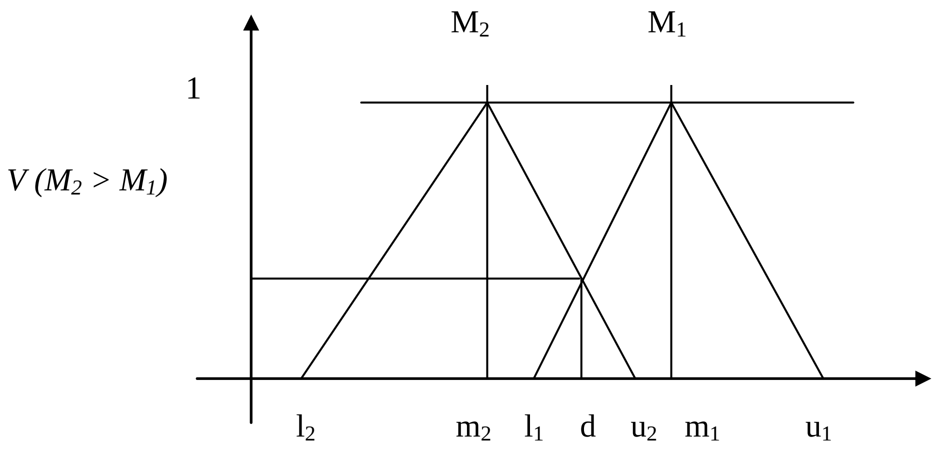
d denotes the stated of the ultimate intersection point D among μ_{M_1} and μ_{M_2} and comparing of M_1 and M_2, we can get rates of $V (M_1 \geq M_2)$ and $V (M_2 \geq M_1)$.

Step 3: The rank of probability for a convex fuzzy number to be bigger than k convex fuzzy numbers M_i (i = 1, 2, …, k) may be determined by

$V(M \geq M_1, M_2, \ldots, M_k) = [V(M \geq M_1)$ and $(M \geq M_2)$ and $(M \geq M_k)]$
$= \min V(M \geq M_i)$, i=1, 2, 3, …, k.

Suppose that

$d'(A_i) = \min V(S_i \geq S_k)$.



4.2 Evaluation of Financial Performance

The primary aim of enterprises in general is to achieve profit and profitability. Evaluating the performance of the marketing of airlines, the relationship between the process of input and service must be linked (Zahra, 1995). The relationship between inputs and outputs used by airlines must be understood correctly to evaluate of performance.

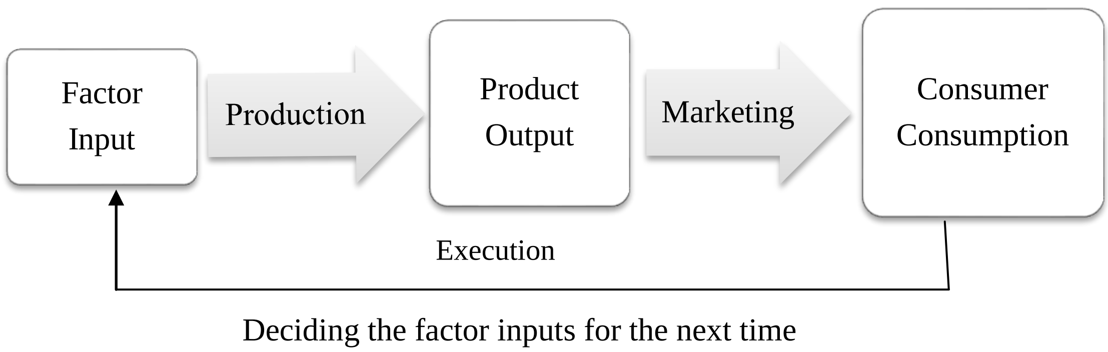


Figure 4.1 Cycle of operation activities of an airline

In Figure 4.1, there are activities of operation of an airline. Operation activities consists of factor input, product output and consumer consumption. The cycle of operation activities of an airline consists of production, marketing and execution.

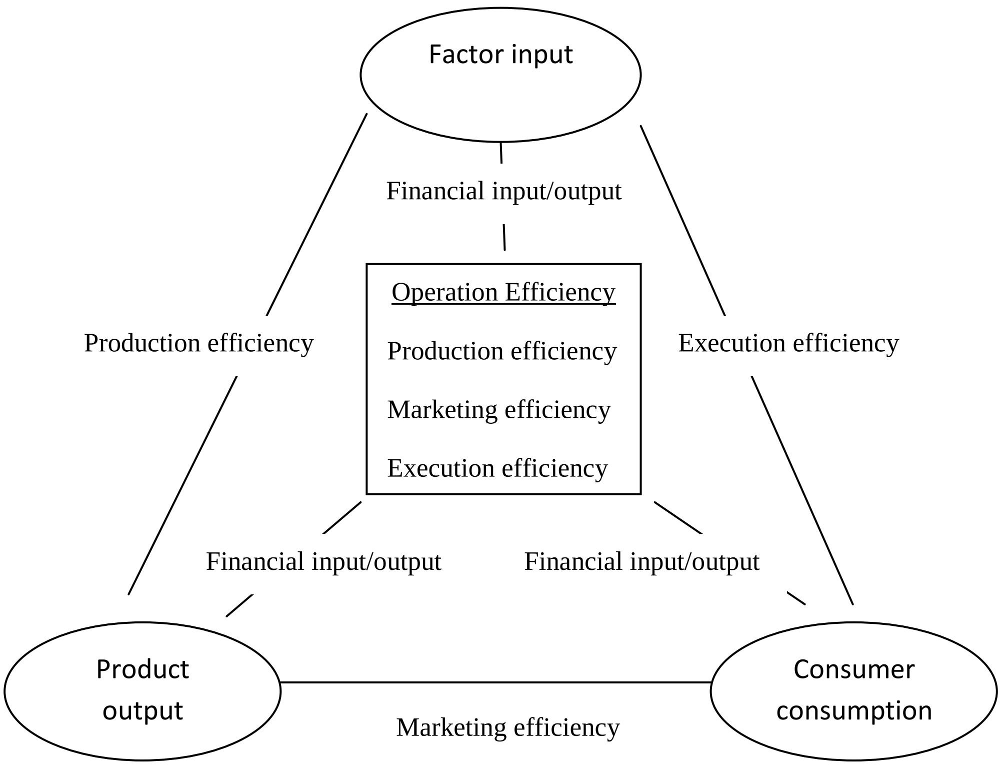


Figure 4.2 The production efficiency of factor input and product output

In Figure 4.2 demonstrates the production efficiency of the factor input and the product output evaluates by using the funds to generate output, for instance, labor productivity, short-term liquidation, and long-term solvency. It may be presented as like the production efficiency deal with departments, for instance the department of manufacturing. The extent is measured by the efficiency of marketing of product output and consumer consumption to that output is utilized, for instance, fleet execution capability, return of investment, and assets and stockholder's turnover. The output is measured by the execution efficiency of consumer consumption and factor input used to the resources employed, for instance, fleet execution capability, return of investment, and assets and stockholder's turnover. It may be performed as the efficiency of departments deal with sales activities, for instance the sales department and marketing department.

According to Walter and Robert (1988), financial statements consists of records about executive performance, attainment or fail and flashing warning and alarm traces of coming challenges.

In the literature, there were some treatments about finance in the efficiency of operation of the airline. At this work, we used performance indicators set which involves financial ratios. Ratio analysis is a method of analysing of financial. This method is an analytical method. Financial analysis has four basic kinds of financial statements including as the following:

a) the balance sheet,
b) the income sheet,
c) the statement of cash flows,
d) and the statement of change in stockholders' equity.

In general, a financial ratio only represents one item divided by other item which are in the financial statement. At first, we made a classification on the basis of five accounting classes as assets, debts, owner's equity, revenue, and expense. The input of factors of financial includes assets and the capital of the owner's equity, output of factors of the financial includes debts and expense, and the outcome of factors of financial includes income/loss.

4.3 Performance Indicators

At this study, we used performance indicators to evaluate financial performance. In previous studies, two basic criteria were utilized to select the indicators. First criterion is an indicator should have a primacy descriptor. Second criterion is one of the indicators is selected as the performance indicator, if a primacy information may be applied to evaluate the high correlation all of valuation indicators.

Foundation over the two selection criteria and the ratios, the set of evaluation indicators consists of 25 performance evaluation indicators. They are separated in three basic classes as production, marketing, and execution.

Performance indicators set in production have two criteria like as short term liquidation and long term solvency. Short-term liquidation has three ratio like current ratio, equity/fixed ratio and equity ratio. Long-term solvency includes fixed/long-term ratio, debt ratio and equity/debt ratio.

Performance indicators set in marketing have two criteria like as profitability and debts turnover. Profitability includes five ratio like as operation cost ratio, gross profit ratio, operation profit ratio, income before tax ratio and net income ratio. Debts turnover has four ratio like as current liabilities turnover, long-term liabilities turnover, total liabilities turnover and interest expense ratio.

Performance indicators set in execution have two criteria like as return of investment and assets and stockholder’s turnover. Return of investment has six ratio like as return on current assets, return on fixed assets, return on total assets, return on stockholders' equity, return on operation profit to capital, return on income before tax to capital. Assets and stockholder’s turnover includes four ratio like as current assets turnover, fixed assets turnover, total assets turnover, stockholders' equity.

4.3.1 Definition of Performance Indicators

There are some definiton of performance indicators which used to evaluate financial performance.

a) Performance indicators set in production

Short-term liquidation

Short-term liquidity ratios take a firm's capable to acquit the short-term debts overdue for the near future and have sufficiency money to sustain its daily processes of the business, for instance, the skill to get over in the short-run.

There are three ratios of Short-term liquidation in Table 4.1;

Table 4.1 Ratios of Short-term liquidation

Short-term liquidation	**Formulation**
Current ratio	Current assets / current liabilities
Equity / fixed ratio	Stockholders' equity / fixed assets
Equity ratio	Stockholders' equity / total assets

Current ratio: The current ratio is balance-sheet performance of financial take liquidity of firm. The current ratio argues the capable of a firm to encounter short term debt loans. This ratio evaluates in any case a company has sufficiency equity to pay for the debts among the next one year. Possible creditors utilize current ratio in describing in any case to take short term obligations. This ratio also presents the feelings of the efficiency of operating cycle of a firm or its resource to revolve its product in cash. This ratio is also called as the working capital ratio**.**

The formula of the current ratio is obtained by dividing current assets to current liabilities:

$$\text{The current ratio} = \frac{\text{Current assets}}{\text{Current liabilities}}$$

Both of these variables present on the balance sheet.

Equity/fixed ratio: Equity to fixed ratio is utilized to assist define how much shareholders would accepted in the event of a company-wide liquidation. The equity to fixed ratio is obtained by dividing equity capital to fixed assets of the firm:

$$\text{Equity/fixed ratio} = \frac{\text{Stockholders}' \text{ equity}}{\text{Fixed assets}}$$

It shows the sum of assets on which shareholders have a equity claim.

Equity ratio: Equity ratio is otherwise of the debt to equity ratio and is also, occasionally, as equity capital to total assets ratio. The equity ratio depends on the capitalize of shareholder to total assets furthermore representation the long term or following solvency statement of the firm.

The formula is applied to calculate equity ratio is:

$$\text{Equity Ratio} = \frac{\text{Stockholders' equity}}{\text{Total assets}}$$

Long-term Solvency

This ratio mentions to in any case a firm may meet its financial loans through a specific period, for instance, 10, 20 or 30 years. Long-term Solvency ratio has three indicators in Table 4.2;

Table 4.2 Ratios of Long-term solvency

Long-term Solvency	**Formulation**
Fixed / long-term ratio	Fixed assets / long term liabilities
Debt ratio	Total assets / total liabilities
Equity / debt ratio	Stockholders' equity / total liabilities

Fixed/long-term ratio: This ratio is constant assets to long term liabilities.

The formula is used to calculate as:

$$\text{Fixed/long} - \text{term ratio} = \frac{\text{Fixed assets}}{\text{Long term liabilities}}$$

Debt ratio: Debt ratio represents the ratio of debt of a firm to its total assets. It indicates how much the firm consists in debt to finance assets. The debt ratio provides to measure the sum of debt quickly.

Debt ratio is same to debt to equity ratio which indicates the similar rate but in other way.

The debt ratio is obtained by dividing total liabilities to total assets:

$$\text{Debt ratio} = \frac{\text{Total assets}}{\text{Total liabilities}}$$

Equity/debt ratio: This ratio is stockholders' equity to total liabilities.

The formula is applied to compute is:

$$\text{Equity/debt ratio} = \frac{\text{Stockholders' equity}}{\text{Total liabilities}}$$

b) Performance indicators set in marketing

Profitability

Profitability ratio takes ability of a firm to produce acquisition relying on assets, equity and sales. This ratio evaluates a firm’s capable to produce acquisition, cash flows and profits, usual the sum of money funded. They underline the ways of the effectively and the profitability of the business is operated.

There are five ratios in Table 4.3;

Table 4.3 Ratios of Profitability

Profitability	**Formulation**
Operation cost ratio	Operation cost / operation revenue
Gross profit ratio	(Operation revenue - operation cost) / operation revenue
Operation profit ratio	Operation income (loss) / operation revenue
Income before tax ratio	Income (loss) before tax / operation revenue
Net income ratio	Net income (loss) / operation revenue

Operation cost ratio: An evaluation of what it costs to manage a part of attribute matched to the income that the attribute provides. The operation cost ratio is computed by dividing operation cost to operation revenue.

$$\text{Operation cost ratio} = \frac{\text{Operation cost}}{\text{Operation revenue}}$$

Gross profit ratio: The gross profit ratio takes the difference between how much it costs to generate a product and the company is pretended it.

The formula is used to compute:

$$\text{Gross profit ratio} = \frac{(\text{Operation revenue} - \text{Operation cost})}{\text{Operation revenue}}$$

Operation profit ratio: This ratio is operation income (loss) to operation revenue.

The formula is used to compute as:

$$\text{Operation profit ratio} = \frac{\text{Operation income (loss)}}{\text{Operation revenue}}$$

Income before tax ratio: Before-tax income is rather easy the income a company makes primacy to taxes being issued.

The formula is used to calculate as:

$$\text{Income before tax ratio} = \frac{\text{Income (loss) before tax}}{\text{Operation revenue}}$$

Net income ratio: Net income ratio means a ratio of profitability. This ratio is computed as net income (loss) divided by operation revenue. It is very useful to compare firms in the same industries.

The formula is used to compute as:

$$\text{Net income ratio} = \frac{\text{Net income (loss)}}{\text{Operation revenue}}$$

Debts turnover

Debts turnover ratio shows the velocity of a company's debt collection. It represents the number of time average assests are converted through over a year. Table 4.4 illustrates ratios of debts turnover.

Table 4.4 Ratios of Debts turnover

Debts turnover	**Formulation**
Current liabilities turnover	Operation revenue / current liabilities
Long - term liabilities turnover	Operation revenue / long term liabilities
Total liabilities turnover	Operation revenue / total liabilities
Interest expense ratio	Operation revenue / interest expense

Current liabilities turnover: This ratio is obtained by dividing operation revenue to current liabilities.

The formula is used to calculate as:

$$\text{Current liabilities turnover} = \frac{\text{Operation revenue}}{\text{Current liabilities}}$$

<u>Long-term liabilities turnover:</u> This ratio is obtained by dividing operation revenue to long-term liabilities.

The formula is used to calculate is:

$$\text{Long} - \text{term liabilities turnover} = \frac{\text{Operation revenue}}{\text{Long} - \text{term liabilities}}$$

<u>Total liabilities turnover:</u> This ratio is obtained by dividing operation revenue to total liabilities.

The formula used to calculate is:

$$\text{Total liabilities turnover} = \frac{\text{Operation revenue}}{\text{Total liabilities}}$$

<u>Interest expense ratio:</u> This ratio is obtained by dividing operation revenue to interest expense.

The formula used to calculate is:

$$\text{Interest expense ratio} = \frac{\text{Operation revenue}}{\text{Interest expense}}$$

c) Performance indicators set in execution

Return of Investment

Return on investment (ROI) measures the performance of a firm. This ratio is used to assess the investment's efficiency. It matches the greatness and timing of the earnings from investment immediately to the greatness and timing of investment costs. It is one of most generally utilized methods to evaluate the financial outcomes of business investments, decisions, or actions. There are six indicators in Table 4.5;

Table 4.5 Ratios of Return of investment

Return of Investment	**Formulation**
Return on current assets	Net income (loss) / current assets
Return on fixed assets	Net income (loss) / fixed assets
Return on total assets	Net income (loss) / total assets
Return on stockholders' equity	Net income (loss) / average stockholders' equity
Return on operation profit to capital	Operation income (loss) / average capital
Return on income before tax to capital	Income before tax / average capital

Return on current assets: This ratio is obtained by dividing net income (loss) to current assets.

The formula is used to obtain:

$$\text{Return on current assets} = \frac{\text{Net income (loss)}}{\text{Current assets}}$$

Return on fixed assets: This ratio is obtained by dividing net income (loss) to fixed assets.

The formula is used to calculate is:

$$\text{Return on fixed assets} = \frac{\text{Net income (loss)}}{\text{Fixed assets}}$$

Return on total assets: This ratio indicates the percentage of benefit which a firm earns relative to its comprehensive funds.

The formula is used to compute as:

$$\text{Return on total assets} = \frac{\text{Net income (loss)}}{\text{Total assets}}$$

Return on stockholders' equity: It mentions a firm's performance through a fiscal year. This ratio is a recovered form of the return of equity which takes the profitability of a firm.

The formula is used to compute as:

$$\text{Return on stockholders' equity} = \frac{\text{Net income (loss)}}{\text{Average stockholders' equity}}$$

Return on operation profit to capital: This ratio is obtained by dividing operation income (loss) to average capital.

The formula is used to calculate is:

$$\text{Return on operation profit to capital} = \frac{\text{Operation income (loss)}}{\text{Average capital}}$$

Return on income before tax to capital: This ratio is obtained by dividing income before tax to average capital.

The formula is used to compute as:

$$\text{Return on income before tax to capital} = \frac{\text{Income before tax}}{\text{Average capital}}$$

Assets and stockholder's turnover

There are four indicators in Table 4.6;

Table 4.6 Ratios of Assets and stockholder's equity

Assets and stockholder's turnover	**Formulation**
Current assets turnover	Operation revenue / current assets
Fixed assets turnover	Operation revenue / fixed assets
Total assets turnover	Operation revenue / total assets
Stockholders' equity	Operation revenue / average stockholders' equity

Current assets turnover: This ratio is obtained by dividing operation revenue to current assets.

The formula is used to compute as:

$$\text{Current assets turnover} = \frac{\text{Operation revenue}}{\text{Current assets}}$$

Fixed assets turnover: This ratio is obtained by dividing operation revenue to fixed assets.

The formula is used to compute as:

$$\text{Fixed assets turnover} = \frac{\text{Operation revenue}}{\text{Fixed assets}}$$

Total assets turnover: This ratio is obtained by dividing operation revenue to total assets.

The formula is used to compute as:

$$\text{Total assets turnover} = \frac{\text{Operation revenue}}{\text{Total assets}}$$

<u>Stockholders' equity:</u> This ratio is obtained by dividing operation revenue to average stockholders' equity.

The formula is used to compute as:

$$\text{Stockholders' equity} = \frac{\text{Operation revenue}}{\text{Average stockholders' equity}}$$

Chapter 5
Case Study

5.1 Aviation Sector in Turkey

Turkey, located at an intersection across continents, has an important and strategic place in international air transport.

The airline industry has entered into a marked improvement from the second half of the 1980s. Modernization and developing service standards of THY, as well as the number of private sector airlines, fleet capacity, and the industry has been a significant increase in their shares. Since the 1990s with the efforts of Turkish Airlines and private companies in the international market share of over 50% was obtained. (SHGM, 1998: 17)

From a market share of the three largest Turkish company in the aviation sector are Turkish Airlines, Pegasus and Onurair. So we compare these companies of financial performance at this study.

5.2 Problem Definition

In this study, we consider three companies like as Turkish Airlines, Pegasus Airlines and Onurair to compare the evaluation of financial performance in Turkey. According to research, market share of these companies is the largest in Turkey so we chose these companies.

We determine three performance indicators set like as production, marketing and execution as we explain in section 4.3.

To evalute the financial performance, we use FAHP method because we had no numerical information about Onurair so there was an uncertainty.

5.3 Application of Fuzzy Analytic Hierarchy Process (FAHP) in Turkey

As mentioned above, we determine six criteria and each criterion has some alternatives. First of all we built a hierarchy which includes the goal up the hill, the criteria and finally the alternatives undermost.

History of Turkish Airlines

Turkish Airlines was founded on the May, 20th in 1933. The beginning budget of the company was 180 thousand Turkish Liras. There was the total of 24 employers which consisted of 7 pilots, 8 mechanics, 8 officers and 1 radio operator employed in the organization. At the present time, Turkish Airline has thousands of employers. The company is famous all around world and Turkish Airlines became the 20th member of Star Alliance.

History of Pegasus Airlines

Pegasus Airlines was established in Istanbul in 1990. The company growed up in a short time. At the present time, the budget of the company is $22.3.

History of Onurair

Onur Havayolları Taşımacılık A.Ş. was founded on the April, 14th in 1992 in Istanbul. Onur Air growed up permanently and increased the number of aircrafts.

We structure the model with three levels. There are 3 criteria, 25 sub-criteria (in section 4.3.1) and 3 alternatives. Figure 5.1 shows goal, criteria and sub-criteria.

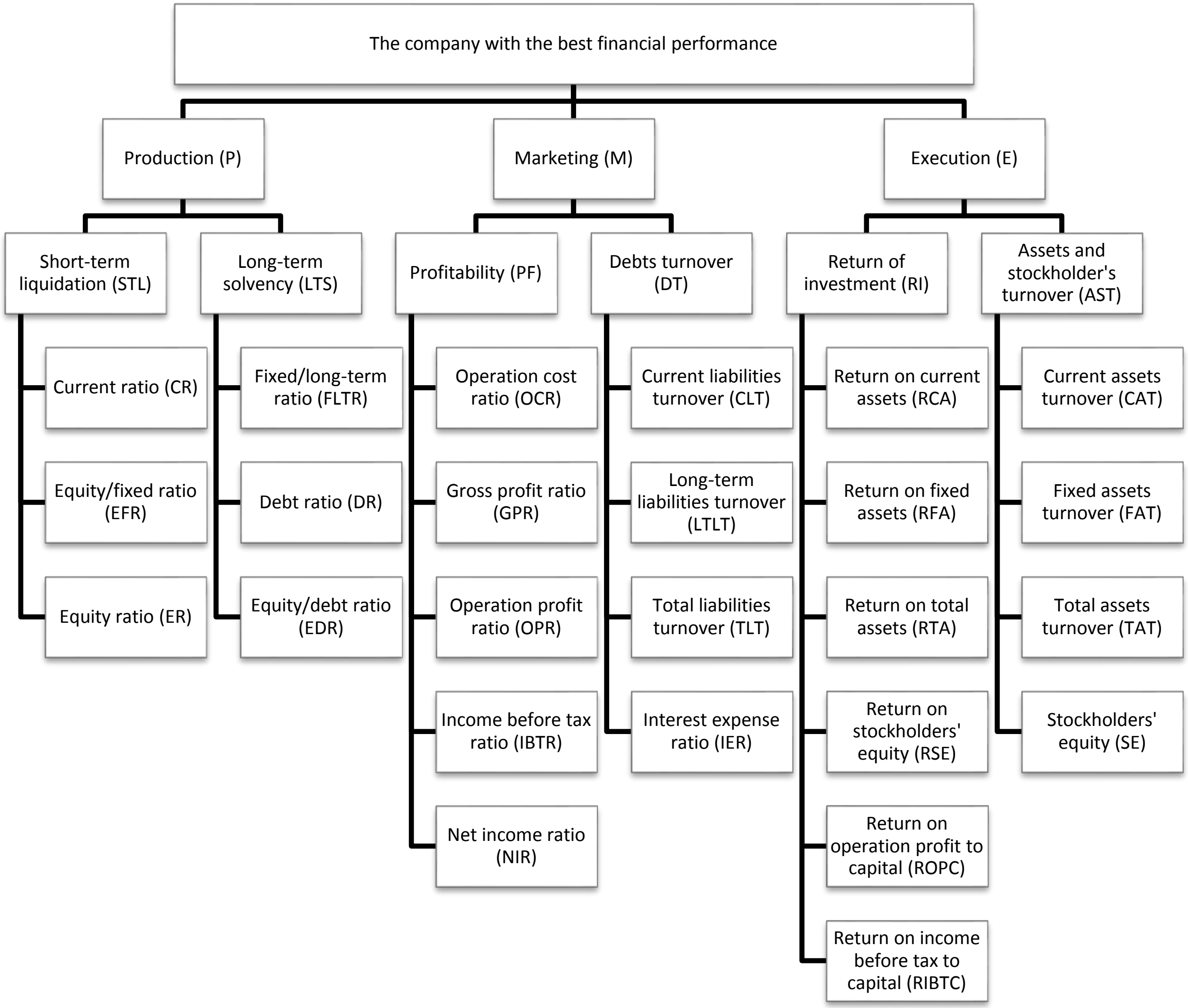


Figure 5.1 The Structure of the Model

At first, we described the main attributes, sub-attributes and alternatives and then we made the structure of the hierarchy of the problem of the supplier selection. Figure 5.2 shows the structure of the hierarchy of the problem of the selection of the company with three levels. The uppermost level, there is the goal of the problem that is selection of the best company with the best financial performance. At the second level there are three members as production, marketing and execution. The third level of hierachy includes main attributions are decopuled into different sub attributions which can influence the company with the best financial performance of choice. The undermost level of the hierarchy, there is three alternates that consist of airline companies.

After the hierarchy is structured, the various primacy weights of every main attribute, sub attribute and alternative were computed by use of the Fuzzy AHP method.

Table 5.1 The linguistic variables and their corresponding fuzzy numbers

Equally preferred (EP)	(1,1,1)
Weakly preferred (WP)	(2/3,1,3/2)
Fairly strongly preferred (FSP)	(3/2,2,5/2)
Very strongly preferred (VSP)	(5/2,3,7/2)
Absolutely preferred (AP)	(7/2,4,9/2)

After the pairwise comparison matrices were established, the consistency of the pairwise opinion of every comparison matrix was controlled by use of the consistency index and consistency ratios in AHP. Table 5.2 shows financial ratios which calculated according to section 4.3.1.

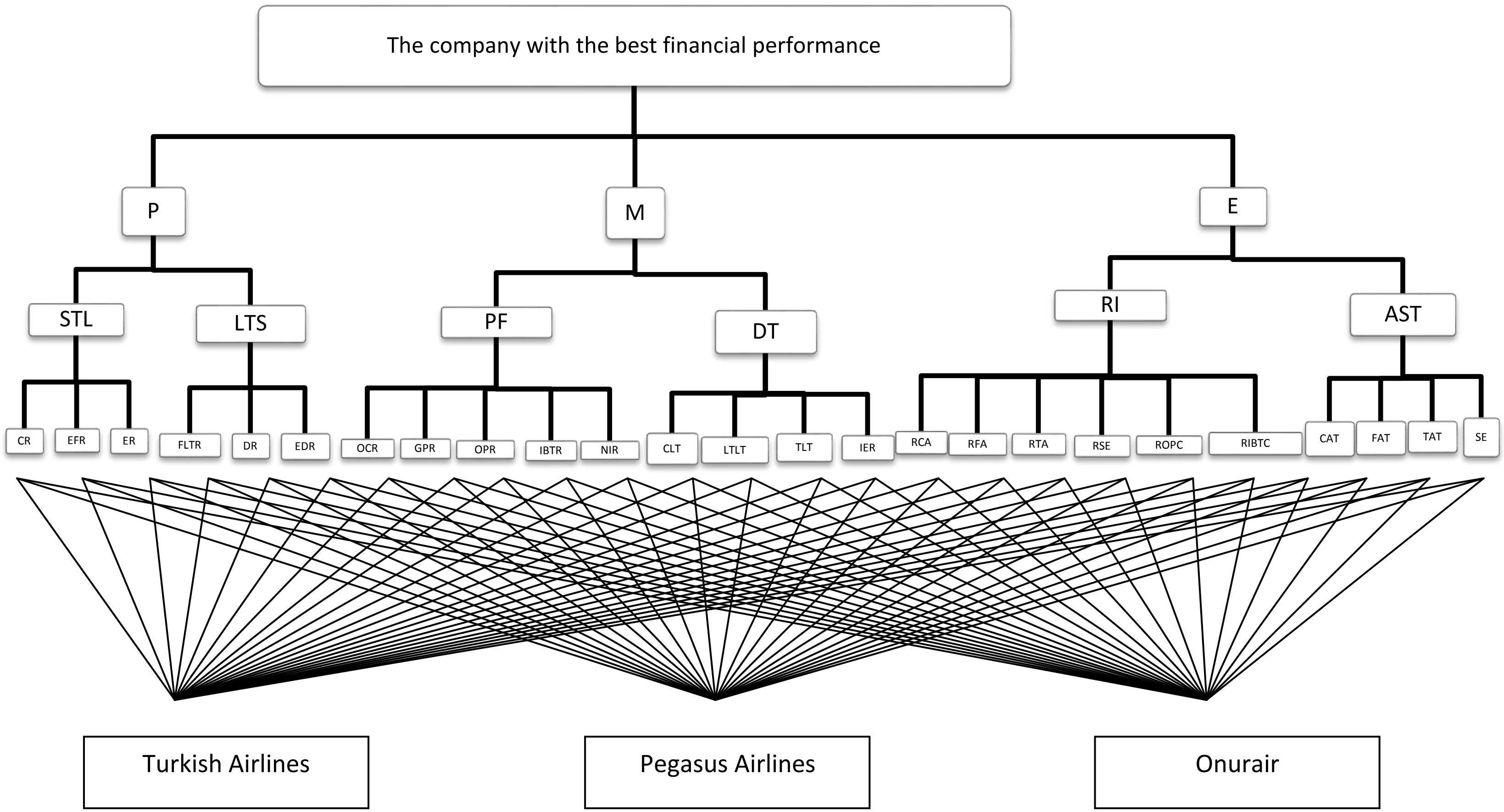


Figure 5.2 The AHP Model of the Problem

Table 5.2 Financial Ratios in production, marketing and execution

Performance indicators set in production

Short-term liquidation	**PEGASUS**	**THY**	**ONURAIR**
Current ratio	1.37	0.27	N/A
Equity/fixed ratio	0.52	0.15	N/A
Equity ratio	0.35	0.14	N/A

Long-term Solvency	**PEGASUS**	**THY**	**ONURAIR**
Fixed/long-term ratio	1.64	1.66	N/A
Debt ratio	1.54	1.15	N/A
Equity/debt ratio	0.54	0.15	N/A

Performance indicators set in marketing

Profitability	**PEGASUS**	**THY**	**ONURAIR**
Operation cost ratio	0.78	0.90	N/A
Gross profit ratio	0.21	0.09	N/A
Operation profit ratio	0.05	0.03	N/A
Income before tax ratio	0.04	0.02	N/A
Net income ratio	0.03	0.02	N/A

Debts turnover	**PEGASUS**	**THY**	**ONURAIR**
Current liabilities turnover	3.31	2.82	N/A
Long-term liabilities turnover	1.93	1.63	N/A
Total liabilities turnover	1.22	1.03	N/A
Interest expense ratio	55.2	64.2	N/A

Performance indicators set in execution

Return of Investment	**PEGASUS**	**THY**	**ONURAIR**
Return on current assets	0.08	0.23	N/A
Return on fixed assets	0.04	0.02	N/A
Return on total assets	0.02	0.02	N/A
Return on stockholders' equity	0.07	0.19	N/A
Return on operation profit to capital	0.51	0.94	N/A
Return on income before tax to capital	0.39	0.67	N/A

Assets and stockholder's turnover	**PEGASUS**	**THY**	**ONURAIR**
Current assets turnover	0.13	0.39	N/A
Fixed assets turnover	0.06	0.03	N/A
Total assets turnover	0.04	0.03	N/A
Stockholders' equity	0.13	0.33	N/A

We calculated Table 5.3-5.38 as regards the method Chang's (1992) extent analysis. Calculations are made by Microsoft Excel.

From Table 5.3

S_{STL} = (3.8, 5.16, 6.83) * (1/54, 1/41.9, 1/32.26) = (0.07, 0.12, 0.21)

S_{LTS} = (3.7, 5, 6.5) * (1/54, 1/41.9, 1/32.26) = (0.06, 0.11, 0.2)

S_{PF} = (3.4, 4.23, 6.16) * (1/54, 1/41.9, 1/32.26) = (0.06, 0.1, 0.19)

S_{DT} = (4.96, 6.5, 8.83) * (1/54, 1/41.9, 1/32.26) = (0.09, 0.15, 0.27)

S_{RI} = (9, 11.5, 14) * (1/54, 1/41.9, 1/32.26) = (0.16, 0.27, 0.43)

S_{AST} = (7.4, 9.5, 11.6) * (1/54, 1/41.9, 1/32.26) = (0.13, 0.22, 0.35)

By use of these vectors,

$V(S_{STL} \geq S_{LTS}) = 0.92$

$V(S_{STL} \geq S_{PF}) = 0.85$

$V(S_{STL} \geq S_{DT}) = 1.00$

$V(S_{STL} \geq S_{RI}) = 1.00$

$V(S_{STL} \geq S_{AST}) = 1.00$

$V(S_{LTS} \geq S_{STL}) = 1.00$

$V(S_{LTS} \geq S_{PF}) = 0.92$

$V(S_{LTS} \geq S_{DT}) = 1.00$

$V(S_{LTS} \geq S_{RI}) = 1.00$

$V(S_{LTS} \geq S_{AST}) = 1.00$

$V(S_{PF} \geq S_{STL}) = 1.00$

$V(S_{PF} \geq S_{LTS}) = 1.00$

$V(S_{PF} \geq S_{DT}) = 1.00$

$V(S_{PF} \geq S_{RI}) = 1.00$

$V(S_{PF} \geq S_{AST}) = 1.00$

$V(S_{DT} \geq S_{STL}) = 0.8$

$V(S_{DT} \geq S_{LTS}) = 0.73$

$V(S_{DT} \geq S_{PF}) = 0.66$

$V(S_{DT} \geq S_{RI}) = 1.00$

$V(S_{DT} \geq S_{AST}) = 1.00$

$V(S_{RI} \geq S_{STL}) = 0.25$

$V(S_{RI} \geq S_{LTS}) = 1.00$

$V(S_{RI} \geq S_{PF}) = 0.2$

$V(S_{RI} \geq S_{DT}) = 0.27$

$V(S_{RI} \geq S_{AST}) = 0.79$

$V(S_{AST} \geq S_{STL}) = 0.44$

$V(S_{AST} \geq S_{LTS}) = 0.38$

$V(S_{AST} \geq S_{DT}) = 0.33$

$V(S_{AST} \geq S_{PF}) = 0.66$

$V(S_{AST} \geq S_{RI}) = 1.00$ are obtained.

So that, the weight vector from Table 5.3 is computed as $W_G = (0.23, 0.25, 0.27, 0.18, 0.05, 0.09)^T$

Table 5.3 The fuzzy evaluation matrix according to the goal

	STL	LTS	PF	DT	RI	AST
STL	(1, 1, 1)	(1/2, 2/3, 1)	(1, 3/2, 2)	(1/2, 1, 3/2)	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)
LTS	(1, 3/2, 2)	(1, 1, 1)	(1/2, 1, 3/2)	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)
PF	(1/2, 2/3, 1)	(2/3, 1, 2)	(1, 1, 1)	(1/2, 2/3, 1)	(1/3, 2/5, 1/2)	(2/5, 1/2, 2/3)
DT	(2/3, 1, 2)	(3/2, 2, 5/2)	(1, 3/2, 2)	(1, 1, 1)	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)
RI	(3/2, 2, 5/2)	(3/2, 2, 5/2)	(2, 5/2, 3)	(3/2, 2, 5/2)	(1, 1, 1)	(3/2, 2, 5/2)
AST	(3/2, 2, 5/2)	(3/2, 2, 5/2)	(3/2, 2, 5/2)	(3/2, 2, 5/2)	(2/5, 1/2, 2/3)	(1, 1, 1)

Table 5.4 Evaluating of the sub attributions as regards production (P)

	STL	**LTS**
STL	(1,1,1)	(2/3, 1, 2)
LTS	(1/2, 1, 3/2)	(1,1,1)

From Table 5.4

S_{STL} = (1.5, 1.66, 2) * (1/5, 1/4.16, 1/3.5) = (0.3, 0.4, 0.57)

S_{LTS} = (2, 2.5, 3) * (1/5, 1/4.16, 1/3.5) = (0.4, 0.6, 0.85)

By use of these vectors, we obtained

$V(S_{STL} \geq S_{LTS}) = 1.00$

$V(S_{LTS} \geq S_{STL}) = 0.45$

So that, the weight vector from Table 5.4 is obtained as $W_P = (0.6, 0.3)^T$

Table 5.5 Evaluating of the sub attributions as regards marketing (M)

	PF	**DT**
PF	(1,1,1)	(2/5, 1/2, 2/3)
DT	(3/2, 2, 5/2)	(1,1,1)

From Table 5.5

S_{PF} = (1.4, 1.5, 1.66) * (1/5.16, 1/4.5, 1/3.9) = (0.27, 0.33, 0.42)

S_{DT} = (2.5, 3, 3.5) * (1/5.16, 1/4.5, 1/3.9) = (0.48, 0.66, 0.89)

By use of these vectors, we obtained

$V(S_{PF} \geq S_{DT}) = 1.00$

$V(S_{DT} \geq S_{PF}) = 0$

So that, the weight vector from Table 5.5 is computed as $W_M = (1.00, 0)^T$

Table 5.6 Evaluating of the sub attributions as regards execution (E)

	RI	**AST**
RI	(1, 1, 1)	(1/3, 2/5, 1/2)
AST	(2, 5/2, 3)	(1, 1, 1)

From Table 5.6

S_{RI} = (1.33, 1.4, 1.5) * (1/5.5, 1/4.9, 1/4.3) = (0.24, 0.28, 0.34)

S_{AST} = (3, 3.5, 4) * (1/5.5, 1/4.9, 1/4.3) = (0.54, 0.71, 0.93)

By use of these vectors, we obtained

$V(S_{RI} \geq S_{AST}) = 1.00$

$V(S_{AST} \geq S_{RI}) = 0$

So that, the weight vector from Table 5.6 is obtained $W_E = (1.00, 0)^T$

Table 5.7 Evaluating of the sub attributions as regards short term liquidation (STL)

	CR	**EFR**	**ER**
CR	(1, 1, 1)	(1, 3/2, 2)	(3/2, 2, 5/2)
EFR	(1/2, 2/3, 1)	(1, 1, 1)	(1/2, 1, 3/2)
ER	(2/5, 1/2, 2/3)	(2/3, 1, 2)	(1, 1, 1)

From Table 5.7

S_{CR} = (3.5, 4.5, 5.5) * (1/12.66, 1/9.66, 1/7,56) = (0.27, 0.46, 0.72)

S_{EFR} = (2, 2.66, 3.5) * (1/12.66, 1/9.66, 1/7,56) = (0.15, 0.27, 0.46)

S_{ER} = (2.06, 2.5, 3.66) * (1/12.66, 1/9.66, 1/7,56) = (0.16, 0.25, 0.48)

By use of these vectors,

$V(S_{CR} \geq S_{EFR}) = 0.5$

$V(S_{CR} \geq S_{ER}) = 0.5$

$V(S_{EFR} \geq S_{CR}) = 1.00$

$V(S_{EFR} \geq S_{ER}) = 0.94$

$V(S_{ER} \geq S_{CR}) = 1.00$

$V(S_{ER} \geq S_{EFR}) = 1.00$ are obtained.

So that, the weight vector from Table 5.7 is computed as $W_{STL} = (0.2, 0.38, 0.4)^T$

Table 5.8 Evaluating of the sub attributions as regards long term solvency (LTS)

	FLTR	**DR**	**EDR**
FLTR	(1, 1, 1)	(1, 3/2, 2)	(5/2, 3, 7/2)
DR	(1/2, 2/3, 1)	(1, 1, 1)	(3/2, 2, 5/2)
EDR	(2/7, 1/3, 2/5)	(2/5, 1/2, 2/3)	(1, 1, 1)

From Table 5.8

S_{FLTR} = (4.5, 5.5, 6.5) * (1/13.07, 1/11, 1/9.19) = (0.34, 0.5, 0.7)

S_{DR} = (3, 3.67, 4.5) * (1/13.07, 1/11, 1/9.19) = (0.22, 0.33, 0.48)

S_{EDR} = (1.69, 1.83, 2.07) * (1/13.07, 1/11, 1/9.19) = (0.12, 0.16, 0.22)

By use of these vectors,

$V(S_{FLTR} \geq S_{DR}) = 0.45$

$V(S_{FLTR} \geq S_{EDR}) = 0$

$V(S_{DR} \geq S_{FLTR}) = 1.00$

$V(S_{DR} \geq S_{EDR}) = 0$

$V(S_{EDR} \geq S_{FLTR}) = 1.00$

$V(S_{EDR} \geq S_{DR}) = 1.00$ are obtained.

So that, the weight vector from Table 5.8 is computed as $W_{LTS} = (0.3, 0, 0{,}68)^T$

Table 5.9 Evaluating of the sub attributions as regards profitability (PF)

	OCR	**GPR**	**OPR**	**IBTR**	**NIR**
OCR	(1, 1, 1)	(1, 3/2, 2)	(3/2, 2, 5/2)	(2, 5/2, 3)	(5/2, 3, 7/2)
GPR	(1/2, 2/3, 1)	(1, 1, 1)	(3/2, 2, 5/2)	(3/2, 2, 5/2)	(3/2, 2, 5/2)
OPR	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)	(1, 1, 1)	(1/2, 1, 3/2)	(1, 3/2, 2)
IBTR	(1/3, 2/5, 1/2)	(2/5, 1/2, 2/3)	(2/3, 1, 2)	(1, 1, 1)	(1/2, 1, 3/2)
NIR	(2/7, 1/3, 2/5)	(2/5, 1/2, 2/3)	(1/2, 2/3, 1)	(2/3, 1, 2)	(1, 1, 1)

From Table 5.9

$S_{OCR} = (8, 10, 12) * (1/38.06, 1/29.56, 1/23.05) = (0.21, 0.33, 0.52)$

$S_{GPR} = (6, 7.66, 9.5) * (1/38.06, 1/29.56, 1/23.05) = (0.15, 0.25, 0.41)$

$S_{OPR} = (3.3, 4.5, 5.83) * (1/38.06, 1/29.56, 1/23.05) = (0.08, 0.15, 0.25)$

$S_{IBTR} = (2.9, 3.9, 5.66) * (1/38.06, 1/29.56, 1/23.05) = (0.07, 0.13, 0.24)$

$S_{NIR} = (3.85, 3.5, 5{,}06) * (1/38.06, 1/29.56, 1/23.05) = (0.1, 0.11, 0.21)$

By use of these vectors, we obtained

$V(S_{OCR} \geq S_{GPR}) = 0.71$

$V(S_{OCR} \geq S_{OPR}) = 0.18$

$V(S_{OCR} \geq S_{IBTR}) = 0.13$

$V(S_{OCR} \geq S_{NIR}) = 0$

$V(S_{GPR} \geq S_{OCR}) = 1.27$

$V(S_{GPR} \geq S_{OPR}) = 0.5$

$V(S_{GPR} \geq S_{IBTR}) = 0.42$

$V(S_{GPR} \geq S_{NIR}) = 0.3$

$V(S_{OPR} \geq S_{OCR}) = 1.00$

$V(S_{OPR} \geq S_{GPR}) = 1.00$

$V(S_{OPR} \geq S_{IBTR}) = 0.88$

$V(S_{OPR} \geq S_{NIR}) = 0.76$

$V(S_{IBTR} \geq S_{OCR}) = 1.00$

$V(S_{IBTR} \geq S_{GPR}) = 1.00$

$V(S_{IBTR} \geq S_{OPR}) = 1.00$

$V(S_{IBTR} \geq S_{NIR}) = 0.87$

$V(S_{NIR} \geq S_{OCR}) = 1.00$

$V(S_{NIR} \geq S_{GPR}) = 1.00$

$V(S_{NIR} \geq S_{OPR}) = 1.00$

$V(S_{NIR} \geq S_{IBTR}) = 1.00$

So that, the weight vector from Table 5.9 is computed as $W_{PR} = (0, 0.1, 0.25, 0.29, 0.34)^T$

Table 5.10 Evaluating of the sub attributions as regards debts turnover (DT)

	CLT	**LTLT**	**TLT**	**IER**
CLT	(1, 1, 1)	(3/2, 2, 5/2)	(2, 5/2, 3)	(2/7, 1/3, 2/5)
LTLT	(2/5, 1/2, 2/3)	(1, 1, 1)	(1, 3/2, 2)	(2/7, 1/3, 2/5)
TLT	(1/3, 2/5, 1/2)	(1/2, 2/3, 1)	(1, 1, 1)	(2/7, 1/3, 2/5)
IER	(5/2, 3, 7/2)	(5/2, 3, 7/2)	(5/2, 3, 7/2)	(1, 1, 1)

From Table 5.10

S_{CLT} = (4.78, 5.83, 6.9) * (1/25.36, 1/21.56, 1/18.09) = (0.18, 0.27, 0.38)

S_{LTLT} = (2.68, 3.33, 4.06) * (1/25.36, 1/21.56, 1/18.09) = (0.1, 0.15, 0.22)

S_{TLT} = (2.11, 2.4, 2.9) * (1/25.36, 1/21.56, 1/18.09) = (0.08, 0.11, 0.16)

S_{IER} = (8.5, 10, 7.02) * (1/25.36, 1/21.56, 1/18.09) = (0.33, 0.46, 0.38)

By use of these vectors, we obtained

$V(S_{CLT} \geq S_{LTLT}) = 0.25$

$V(S_{CLT} \geq S_{TLT}) = 0$

$V(S_{CLT} \geq S_{IER}) = 1.00$

$V(S_{LTLT} \geq S_{CLT}) = 1.00$

$V(S_{LTLT} \geq S_{TLT}) = 0.06$

$V(S_{LTLT} \geq S_{IER}) = 1.00$

$V(S_{TLT} \geq S_{CLT}) = 1.00$

$V(S_{TLT} \geq S_{LTLT}) = 1.00$

$V(S_{TLT} \geq S_{IER}) = 1.00$

$V(S_{IER} \geq S_{CLT}) = 0.2$

$V(S_{IER} \geq S_{LTLT}) = 0$

$V(S_{IER} \geq S_{TLT}) = 0$

So that, the weight vector from Table 5.10 is computed as $W_{DT} = (0, 0.05, 0.94, 0)^T$

Table 5.11 Evaluating of the sub attributes according to return of investment (RI)

	RCA	**RFA**	**RTA**	**RSE**	**ROPC**	**RIBTC**
RCA	(1, 1, 1)	(1/2, 2/3, 1)	(1, 3/2, 2)	(1/2, 1, 3/2)	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)
RFA	(1, 3/2, 2)	(1, 1, 1)	(1/2, 1, 3/2)	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)
RTA	(1/2, 2/3, 1)	(2/3, 1, 2)	(1, 1, 1)	(1/2, 2/3, 1)	(1/3, 2/5, 1/2)	(2/5, 1/2, 2/3)
RSE	(2/3, 1, 2)	(3/2, 2, 5/2)	(1, 3/2, 2)	(1, 1, 1)	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)
ROPC	(3/2, 2, 5/2)	(3/2, 2, 5/2)	(2, 5/2, 3)	(3/2, 2, 5/2)	(1, 1, 1)	(3/2, 2, 5/2)
RIBTC	(3/2, 2, 5/2)	(3/2, 2, 5/2)	(3/2, 2, 5/2)	(3/2, 2, 5/2)	(2/5, 1/2, 2/3)	(1, 1, 1)

From Table 5.11

S_{RCA} = (3.8, 5.16, 6.83) * (1/54, 1/41.9, 1/32.26) = (0.07, 0.12, 0.21)

S_{RFA} = (3.7, 5, 6.5) * (1/54, 1/41.9, 1/32.26) = (0.06, 0.11, 0.2)

S_{RTA} = (3.4, 4.23, 6.16) * (1/54, 1/41.9, 1/32.26) = (0.06, 0.1, 0.19)

S_{RSE} = (4.96, 6.5, 8.83) * (1/54, 1/41.9, 1/32.26) = (0.09, 0.15, 0.27)

S_{ROPC} = (9, 11.5, 14) * (1/54, 1/41.9, 1/32.26) = (0.16, 0.27, 0.43)

S_{RIBTC} = (7.4, 9.5, 11.6) * (1/54, 1/41.9, 1/32.26) = (0.13, 0.22, 0.35)

By use of these vectors,

$V(S_{RCA} \geq S_{RFA}) = 0.92$

$V(S_{RCA} \geq S_{RTA}) = 0.85$

$V(S_{RCA} \geq S_{RSE}) = 1.00$

$V(S_{RCA} \geq S_{ROPC}) = 1.00$

$V(S_{RCA} \geq S_{RIBTC}) = 1.00$

$V(S_{RFA} \geq S_{RCA}) = 1.00$

$V(S_{RFA} \geq S_{RTA}) = 0.92$

$V(S_{RFA} \geq S_{RSE}) = 1.00$

$V(S_{RFA} \geq S_{ROPC}) = 1.00$

$V(S_{RFA} \geq S_{RIBTC}) = 1.00$

$V(S_{RTA} \geq S_{RCA}) = 1.00$

$V(S_{RTA} \geq S_{RFA}) = 1.00$

$V(S_{RTA} \geq S_{RSE}) = 1.00$

$V(S_{RTA} \geq S_{ROPC}) = 1.00$

$V(S_{RTA} \geq S_{RIBTC}) = 1.00$

$V(S_{RSE} \geq S_{RCA}) = 0.8$

$V(S_{RSE} \geq S_{RFA}) = 0.73$

$V(S_{RSE} \geq S_{RTA}) = 0.66$

$V(S_{RSE} \geq S_{ROPC}) = 1.00$

$V(S_{RSE} \geq S_{RIBTC}) = 1.00$

$V(S_{ROPC} \geq S_{RCA}) = 0.25$

$V(S_{ROPC} \geq S_{RFA}) = 1.00$

$V(S_{ROPC} \geq S_{RTA}) = 0.2$

$V(S_{ROPC} \geq S_{RSE}) = 0.27$

$V(S_{ROPC} \geq S_{RIBTC}) = 0.79$

$V(S_{RIBTC} \geq S_{RCA}) = 0.44$

$V(S_{RIBTC} \geq S_{RFA}) = 0.38$

$V(S_{RIBTC} \geq S_{RTA}) = 0.33$

$V(S_{RIBTC} \geq S_{RSE}) = 0.66$

$V(S_{RIBTC} \geq S_{ROPC}) = 1.00$ are obtained.

So that, the weight vector from Table 5.11 is computed as $W_{RI} = (0.23, 0.25, 0.27, 0.18, 0.05, 0.09)^T$

Table 5.12 Evaluating of the sub attributions according to assets and stockholders' turnover (AST)

	CAT	**FAT**	**TAT**	**SE**
CAT	(1, 1, 1)	(3/2, 2, 5/2)	(2, 5/2, 3)	(1/2, 1, 3/2)
FAT	(2/5, 1/2, 2/3)	(1, 1, 1)	(1, 3/2, 2)	(1/3, 2/5, 1/2)
TAT	(1/3, 2/5, 1/2)	(1/2, 2/3, 1)	(1, 1, 1)	(2/5, 1/2, 2/3)
SE	(2/3, 1, 2)	(2, 5/2, 3)	(3/2, 2, 5/2)	(1, 1, 1)

From Table 5.12

S_{CAT} = (5, 6.5, 8) * (1/23.83, 1/18.96, 1/15.13) = (0.2, 0.34, 0.52)

S_{FAT} = (2.73, 3.4, 4.16) * (1/23.83, 1/18.96, 1/15.13) = (0.11, 0.17, 0.27)

S_{TAT} = (2.23, 2.56, 3.16) * (1/23.83, 1/18.96, 1/15.13) = (0.09, 0.13, 0.2)

S_{SE} = (5.16, 6.5, 8.5) * (1/23.83, 1/18.96, 1/15.13) = (0.21, 0.34, 0.56)

By use of these vectors, we obtained

$V(S_{CAT} \geq S_{FAT}) = 0.29$

$V(S_{CAT} \geq S_{TAT}) = 0$

$V(S_{CAT} \geq S_{SE}) = 1.00$

$V(S_{FAT} \geq S_{CAT}) = 1.00$

$V(S_{FAT} \geq S_{TAT}) = 0.69$

$V(S_{FAT} \geq S_{SE}) = 1.00$

$V(S_{TAT} \geq S_{CAT}) = 1.00$

$V(S_{TAT} \geq S_{FAT}) = 1.00$

$V(S_{TAT} \geq S_{SE}) = 1.00$

$V(S_{SE} \geq S_{CAT}) = 1.00$

$V(S_{SE} \geq S_{FAT}) = 0.26$

$V(S_{SE} \geq S_{TAT}) = 0$

So that, the weight vector from Table 5.12 is obtained as $W_{AST} = (0, 0.4, 0.59, 0)^T$

Table 5.13 Evaluating of the airline firms as regards current ratio (CR)

	PEGASUS	**THY**	**ONURAIR**
PEGASUS	(1, 1, 1)	(5/2, 3, 7/2)	(3/2, 2, 5/2)
THY	(2/7, 1/3, 2/5)	(1, 1, 1)	(2/5, 1/2, 2/3)
ONURAIR	(2/5, 1/2, 2/3)	(3/2, 2, 5/2)	(1, 1, 1)

From Table 5.13

$S_{PEGASUS} = (5, 6, 7) * (1/13.23, 1/11.33, 1/9.59) = (0.37, 0.52, 0.72)$

$S_{THY} = (1.69, 1.83, 2.07) * (1/13.23, 1/11.33, 1/9.59) = (0.12, 0.16, 0.21)$

$S_{ONURAIR} = (2.9, 3.5, 4.17) * (1/13.23, 1/11.33, 1/9.59) = (0.21, 0.3, 0.43)$

By use of these vectors,

$V(S_{PEGASUS} \geq S_{THY}) = 0$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 0.21$

$V(S_{THY} \geq S_{PEGASUS}) = 1.00$

$V(S_{THY} \geq S_{ONURAIR}) = 1.82$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 1.00$

$V(S_{ONURAIR} \geq S_{THY}) = 0$ are obtained.

So that, the weight vector from Table 5.13 is obtained as $W_{CR} = (0, 1.00, 0)$

Table 5.14 Evaluating of the airline firms as regards equity/fixed ratio (EFR)

	PEGASUS	**THY**	**ONURAIR**
PEGASUS	(1, 1, 1)	(5/2, 3, 7/2)	(3/2, 2, 5/2)
THY	(2/7, 1/3, 2/5)	(1, 1, 1)	(1/2, 2/3, 1)
ONURAIR	(2/5, 1/2, 2/3)	(1, 3/2, 2)	(1, 1, 1)

From Table 5.14

$S_{PEGASUS} = (5, 6, 7) * (1/13.07, 1/11, 1/9.19) = (0.38, 0.54, 0.76)$

$S_{THY} = (1.79, 2, 2.4) * (1/13.07, 1/11, 1/9.19) = (0.13, 0.18, 0.26)$

$S_{ONURAIR} = (2.4, 3, 3.67) * (1/13.07, 1/11, 1/9.19) = (0.18, 0.27, 0.39)$

By use of these vectors, we obtained

$V(S_{PEGASUS} \geq S_{THY}) = 0$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 0.03$

$V(S_{THY} \geq S_{PEGASUS}) = 1.00$

$V(S_{THY} \geq S_{ONURAIR}) = 1.00$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 1.8$

$V(S_{ONURAIR} \geq S_{THY}) = 0.47$

So that, the weight vector from Table 5.14 is obtained as $W_{EFR} = (0, 0.68, 0.31)^T$

Table 5.15 Evaluating of the airline firms as regards equity ratio (ER)

	PEGASUS	THY	ONURAIR
PEGASUS	(1, 1, 1)	(3/2, 2, 5/2)	(1, 3/2, 2)
THY	(2/5, 1/2, 2/3)	(1, 1, 1)	(2/3, 1, 2)
ONURAIR	(1/2, 2/3, 1)	(1/2, 1, 3/2)	(1, 1, 1)

From Table 5.15

$S_{PEGASUS}$ = (3.5, 4.5, 5.5) * (1/12.67, 1/9.67, 1/7.57) = (0.27, 0.46, 0.72)

S_{THY} = (2.07, 2.5, 3.67) * (1/12.67, 1/9.67, 1/7.57) = (0.16, 0.25, 0.48)

$S_{ONURAIR}$ = (0.15, 0.27, 0.46) * (1/12.67, 1/9.67, 1/7.57) = (0.15, 0.27, 0.46)

By use of these vectors, we obtained

$V(S_{PEGASUS} \geq S_{THY}) = 0.5$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 0.5$

$V(S_{THY} \geq S_{PEGASUS}) = 1.00$

$V(S_{THY} \geq S_{ONURAIR}) = 1.00$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 1.00$

$V(S_{ONURAIR} \geq S_{THY}) = 0.94$

So that, the weight vector from Table 5.15 is obtained as $W_{ER} = (0.2, 0.4, 0.38)^T$

Table 5.16 Evaluating of the airline firms as regards fixed/long term ratio (FLTR)

	PEGASUS	THY	ONURAIR
PEGASUS	(1, 1, 1)	(2/3, 1, 2)	(1, 3/2, 2)
THY	(1/2, 1, 3/2)	(1, 1, 1)	(1, 3/2, 2)
ONURAIR	(1/2, 2/3, 1)	(1/2, 2/3, 1)	(1, 1, 1)

From Table 5.16

$S_{PEGASUS}$ = (2.67, 3.5, 5) * (1/12.5, 1/9.33, 1/7.17) = (0.21, 0.37, 0.69)

S_{THY} = (2.5, 3.5, 4.5) * (1/12.5, 1/9.33, 1/7.17) = (0.2, 0.37, 0.62)

$S_{ONURAIR}$ = (0.16, 0.25, 0.41) * (1/12.5, 1/9.33, 1/7.17) = (0.16, 0.25, 0.41)

By use of these vectors,

$V(S_{PEGASUS} \geq S_{THY}) = 1.00$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 0.62$

$V(S_{THY} \geq S_{PEGASUS}) = 1.00$

$V(S_{THY} \geq S_{ONURAIR}) = 0.63$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 1.00$

$V(S_{ONURAIR} \geq S_{THY}) = 1.00$ are obtained.

So that, the weight vector from Table 5.16 is computed as $W_{FLTR} = (0.27, 0.28, 0.44)^T$

Table 5.17 Evaluating of the airline firms as regards debt ratio (DR)

	PEGASUS	**THY**	**ONURAIR**
PEGASUS	(1, 1, 1)	(5/2, 3, 7/2)	(5/2, 3, 7/2)
THY	(2/7, 1/3, 2/5)	(1, 1, 1)	(1/2, 2/3, 1)
ONURAIR	(2/7, 1/3, 2/5)	(1, 3/2, 2)	(1, 1, 1)

From Table 5.17

$S_{PEGASUS}$ = (6, 7, 8) * (1/13.8, 1/11.83, 1/10.07) = (0.43, 0.59, 0.79)

S_{THY} = (1.79, 2, 2.4) * (1/13.8, 1/11.83, 1/10.07) = (0.12, 0.16, 0.23)

$S_{ONURAIR}$ = (2.29, 2.83, 3.4) * (1/13.8, 1/11.83, 1/10.07) = (0.16, 0.23, 0.33)

By use of these vectors,

$V(S_{PEGASUS} \geq S_{THY}) = 0$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 0$

$V(S_{THY} \geq S_{PEGASUS}) = 1.00$

$V(S_{THY} \geq S_{ONURAIR}) = 1.00$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 1.00$

$V(S_{ONURAIR} \geq S_{THY}) = 0.5$ are obtained.

So that, the weight vector from Table 5.17 is computed as $W_{DR} = (0, 0.66, 0.33)^T$

Table 5.18 Evaluating of the airline firms with respect to equity/debt ratio (EDR)

	PEGASUS	**THY**	**ONURAIR**
PEGASUS	(1, 1, 1)	(5/2, 3, 7/2)	(2, 5/2, 3)
THY	(2/7, 1/3, 2/5)	(1, 1, 1)	(1/2, 2/3, 1)
ONURAIR	(1/3, 2/5, 1/2)	(1, 3/2, 2)	(1, 1, 1)

From Table 5.18

$S_{PEGASUS}$ = (5.5, 6.5, 7.5) * (1/13.4, 1/11.4, 1/9.62) = (0.41, 0.57, 0.77)

S_{THY} = (1.79, 2, 2.4) * (1/13.4, 1/11.4, 1/9.62) = (0.13, 0.17, 0.24)

$S_{ONURAIR}$ = (2.33, 2.9, 3.5) * (1/13.4, 1/11.4, 1/9.62) = (0.17, 0.25, 0.36)

By use of these vectors,

$V(S_{PEGASUS} \geq S_{THY}) = 0$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 0$

$V(S_{THY} \geq S_{PEGASUS}) = 1.00$

$V(S_{THY} \geq S_{ONURAIR}) = 1.00$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 1.00$

$V(S_{ONURAIR} \geq S_{THY}) = 0.46$ are obtained.

So that, the weight vector from Table 5.18 is computed as $W_{EDR} = (0, 0.68, 0.31)^T$

Table 5.19 Evaluating of the airline firms as regards operation cost ratio (OCR)

	PEGASUS	**THY**	**ONURAIR**
PEGASUS	(1, 1, 1)	(1/2, 2/3, 1)	(1/2, 2/3, 1)
THY	(1/2, 1, 3/2)	(1, 1, 1)	(1/2, 2/3, 1)
ONURAIR	(1, 3/2, 2)	(1, 3/2, 2)	(1, 1, 1)

From Table 5.19

$S_{PEGASUS} = (2, 2.33, 3) * (1/11.5, 1/9, 1/7) = (0.17, 0.25, 0.42)$

$S_{THY} = (2, 2.67, 3.5) * (1/11.5, 1/9, 1/7) = (0.17, 0.29, 0.5)$

$S_{ONURAIR} = (3, 4, 5) * (1/11.5, 1/9, 1/7) = (0.26, 0.44, 0.71)$

By use of these vectors, we obtained

$V(S_{PEGASUS} \geq S_{THY}) = 1.00$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 1.00$

$V(S_{THY} \geq S_{PEGASUS}) = 0.86$

$V(S_{THY} \geq S_{ONURAIR}) = 1.00$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 0.45$

$V(S_{ONURAIR} \geq S_{THY}) = 0.61$

So that, the weight vector from Table 5.19 is computed as $W_{OCR} = (0.43, 0.37, 0.19)^T$

Table 5.20 Evaluating of the airline firms as regards gross profit ratio (GFR)

	PEGASUS	**THY**	**ONURAIR**
PEGASUS	(1, 1, 1)	(2, 5/2, 3)	(5/2, 3, 7/2)
THY	(1/3, 2/5, 1/2)	(1, 1, 1)	(1, 3/2, 2)
ONURAIR	(2/7, 1/3, 2/5)	(1/2, 2/3, 1)	(1, 1, 1)

From Table 5.20

$S_{PEGASUS} = (5.5, 6.5, 7.5) * (1/13.4, 1/11.4, 1/9.62) = (0.41, 0.57, 0.77)$

$S_{THY} = (2.33, 2.9, 3.5) * (1/13.4, 1/11.4, 1/9.62) = (0.17, 0.25, 0.36)$

$S_{ONURAIR} = (1.79, 2, 2.4) * (1/13.4, 1/11.4, 1/9.62) = (0.13, 0.17, 0.24)$

By use of these vectors,

$V(S_{PEGASUS} \geq S_{THY}) = 0$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 0$

$V(S_{THY} \geq S_{PEGASUS}) = 1.00$

$V(S_{THY} \geq S_{ONURAIR}) = 0.46$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 1.00$

$V(S_{ONURAIR} \geq S_{THY}) = 1.00$ are obtained.

So that, the weight vector from Table 5.20 is computed as $W_{GPR} = (0, 0.31, 0.68)^T$

Table 5.21 Evaluating of the airline firms as regards operation profit ratio (OPR)

	PEGASUS	**THY**	**ONURAIR**
PEGASUS	(1, 1, 1)	(3/2, 2, 5/2)	(2, 5/2, 3)
THY	(2/5, 1/2, 2/3)	(1, 1, 1)	(3/2, 2, 5/2)
ONURAIR	(1/3, 2/5, 1/2)	(2/5, 1/2, 2/3)	(1, 1, 1)

From Table 5.21

$S_{PEGASUS}$ = (4.5, 5.5, 6.5) * (1/12.83, 1/10.9, 1/9.13) = (0.35, 0.5, 0.71)

S_{THY} = (2.9, 3.5, 4.17) * (1/12.83, 1/10.9, 1/9.13) = (0.22, 0.32, 0.45)

$S_{ONURAIR}$ = (1.73, 1.9, 2.17) * (1/12.83, 1/10.9, 1/9.13) = (0.13, 0.17, 0.23)

By use of these vectors,

$V(S_{PEGASUS} \geq S_{THY}) = 0.35$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 0$

$V(S_{THY} \geq S_{PEGASUS}) = 1.00$

$V(S_{THY} \geq S_{ONURAIR}) = 0.06$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 1.00$

$V(S_{ONURAIR} \geq S_{THY}) = 1.00$ are obtained.

So that, the weight vector from Table 5.21 is obtained as $W_{OPR} = (0, 0.05, 0.94)^T$

Table 5.22 Evaluating of the airline firms as regards income before tax ratio (IBTR)

	PEGASUS	**THY**	**ONURAIR**
PEGASUS	(1, 1, 1)	(3/2, 2, 5/2)	(1, 3/2, 2)
THY	(2/5, 1/2, 2/3)	(1, 1, 1)	(1/2, 2/3, 1)
ONURAIR	(1/2, 2/3, 1)	(1, 3/2, 2)	(1, 1, 1)

From Table 5.22

$S_{PEGASUS}$ = (3.5, 4.5, 5.5) * (1/12.17, 1/9.83, 1/7.9) = (0.28, 0.45, 0.69)

S_{THY} = (1.9, 2.17, 2.67) * (1/12.17, 1/9.83, 1/7.9) = (0.15, 0.22, 0.33)

$S_{ONURAIR}$ = (2.5, 3.17, 4) * (1/12.17, 1/9.83, 1/7.9) = (0.2, 0.32, 0.5)

By use of these vectors, we obtained

$V(S_{PEGASUS} \geq S_{THY}) = 0.17$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 0.62$

$V(S_{THY} \geq S_{PEGASUS}) = 1.00$

$V(S_{THY} \geq S_{ONURAIR}) = 1.00$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 1.00$

$V(S_{ONURAIR} \geq S_{THY}) = 0.56$

So that, the weight vector from Table 5.22 is computed as $W_{IBTR} = (0.09, 0.57, 0.32)^T$

Table 5.23 Evaluating of the airline firms as regards net income ratio (NIR)

	PEGASUS	**THY**	**ONURAIR**
PEGASUS	(1, 1, 1)	(1, 3/2, 2)	(1/2, 2/3, 1)
THY	(1/2, 2/3, 1)	(1, 1, 1)	(2/5, 1/2, 2/3)
ONURAIR	(1, 3/2, 2)	(3/2, 2, 5/2)	(1, 1, 1)

From Table 5.23

$S_{PEGASUS}$ = (2.5, 3.17, 4) * (1/12.17, 1/9.83, 1/7.9) = (0.2, 0.32, 0.5)

S_{THY} = (1.9, 2.17, 2.67) * (1/12.17, 1/9.83, 1/7.9) = (0.15, 0.22, 0.33)

$S_{ONURAIR}$ = (3.5, 4.5, 5.5) * (1/12.17, 1/9.83, 1/7.9) = (0.28, 0.45, 0.69)

By use of these vectors, we obtained

$V(S_{PEGASUS} \geq S_{THY}) = 0.56$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 1.00$

$V(S_{THY} \geq S_{PEGASUS}) = 1.00$

$V(S_{THY} \geq S_{ONURAIR}) = 1.00$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 0.62$

$V(S_{ONURAIR} \geq S_{THY}) = 0.17$

So that, the weight vector from Table 5.23 is computed as $W_{NIR} = (0.32, 0.57, 0.09)^T$

Table 5.24 Evaluating of the airline firms as regards current liabilities turnover (CLT)

	PEGASUS	THY	ONURAIR
PEGASUS	(1, 1, 1)	(3/2, 2, 5/2)	(1/3, 2/5, 1/2)
THY	(2/5, 1/2, 2/3)	(1, 1, 1)	(2/7, 1/3, 2/5)
ONURAIR	(2, 5/2, 3)	(5/2, 3, 7/2)	(1, 1, 1)

From Table 5.24

$S_{PEGASUS}$ = (2.83, 3.4, 4) * (1/13.57, 1/11.73, 1/10.02) = (0.2, 0.28, 0.39)

S_{THY} = (1.69, 1.83, 2.07) * (1/13.57, 1/11.73, 1/10.02) = (0.12, 0.15, 0.2)

$S_{ONURAIR}$ = (5.5, 6.5, 7.5) * (1/13.57, 1/11.73, 1/10.02) = (0.4, 0.55, 0.74)

By use of these vectors, we obtained

$V(S_{PEGASUS} \geq S_{THY}) = 0$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 1.00$

$V(S_{THY} \geq S_{PEGASUS}) = 1.00$

$V(S_{THY} \geq S_{ONURAIR}) = 1.00$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 0$

$V(S_{ONURAIR} \geq S_{THY}) = 0$

So that, the weight vector from Table 5.24 is computed as $W_{CLT} = (0, 1.00, 0)^T$

Table 5.25 Evaluating of the airline firms in comparison with long-term liabilities turnover (LTLT)

	PEGASUS	**THY**	**ONURAIR**
PEGASUS	(1, 1, 1)	(1, 3/2, 2)	(2/7, 1/3, 2/5)
THY	(1/2, 2/3, 1)	(1, 1, 1)	(2/7, 1/3, 2/5)
ONURAIR	(5/2, 3, 7/2)	(5/2, 3, 7/2)	(1, 1, 1)

From Table 5.25

$S_{PEGASUS} = (2.29, 2.83, 3.4) * (1/13.8, 1/11.83, 1/10.07) = (0.16, 0.23, 0.33)$

$S_{THY} = (1.79, 2, 2.4) * (1/13.8, 1/11.83, 1/10.07) = (0.12, 0.16, 0.23)$

$S_{ONURAIR} = (6, 7, 8) * (1/13.8, 1/11.83, 1/10.07) = (0.43, 0.59, 0.79)$

By use of these vectors, we obtained

$V(S_{PEGASUS} \geq S_{THY}) = 0.25$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 1.00$

$V(S_{THY} \geq S_{PEGASUS}) = 1.00$

$V(S_{THY} \geq S_{ONURAIR}) = 1.00$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 0$

$V(S_{ONURAIR} \geq S_{THY}) = 0$

So that, the weight vector from Table 5.25 is computed as $W_{LTLT} = (0.2, 0.8, 0)^T$

Table 5.26 Evaluating of the airline firms in comparison with to total liabilities turnover (TLT)

	PEGASUS	**THY**	**ONURAIR**
PEGASUS	(1, 1, 1)	(3/2, 2, 5/2)	(1/3, 2/5, 1/2)
THY	(2/5, 1/2, 2/3)	(1, 1, 1)	(2/7, 1/3, 2/5)
ONURAIR	(2, 5/2, 3)	(5/2, 3, 7/2)	(1, 1, 1)

From Table 5.26

$S_{PEGASUS} = (2.83, 3.4, 4) * (1/13.57, 1/11.73, 1/10.02) = (0.2, 0.28, 0.39)$

$S_{THY} = (1.69, 1.83, 2.07) * (1/13.57, 1/11.73, 1/10.02) = (0.12, 0.15, 0.2)$

$S_{ONURAIR} = (5.5, 6.5, 7.5) * (1/13.57, 1/11.73, 1/10.02) = (0.4, 0.55, 0.74)$

By use of these vectors, we obtained

$V(S_{PEGASUS} \geq S_{THY}) = 0$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 1.00$

$V(S_{THY} \geq S_{PEGASUS}) = 1.00$

$V(S_{THY} \geq S_{ONURAIR}) = 1.00$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 0$

$V(S_{ONURAIR} \geq S_{THY}) = 0$

So that, the weight vector from Table 5.26 is computed as $W_{TLT} = (0, 1.00, 0)^T$

Table 5.27 Evaluating of the airline firms in comparison with interest expense ratio (IER)

	PEGASUS	THY	ONURAIR
PEGASUS	(1, 1, 1)	(2/5, 1/2, 2/3)	(5/2, 3, 7/2)
THY	(3/2, 2, 5/2)	(1, 1, 1)	(5/2, 3, 7/2)
ONURAIR	(2/7, 1/3, 2/5)	(2/7, 1/3, 2/5)	(1, 1, 1)

From Table 5.27

$S_{PEGASUS}$ = (3.9, 4.5, 5.17) * (1/13.97, 1/12.17, 1/10.47) = (0.27, 0.36, 0.49)

S_{THY} = (5, 6, 7) * (1/13.97, 1/12.17, 1/10.47) = (0.35, 0.49, 0.66)

$S_{ONURAIR}$ = (1.57, 1.67, 1.8) * (1/13.97, 1/12.17, 1/10.47) = (0.11, 0.13, 0.17)

By use of these vectors,

$V(S_{PEGASUS} \geq S_{THY}) = 1.00$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 0$

$V(S_{THY} \geq S_{PEGASUS}) = 0$

$V(S_{THY} \geq S_{ONURAIR}) = 0$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 1.00$

$V(S_{ONURAIR} \geq S_{THY}) = 1.00$ are obtained.

So that, the weight vector from Table 5.27 is computed as $W_{IER} = (0, 0, 1.00)^T$

Table 5.28 Evaluating of the airline firms in comparison with return on current assets (RCA)

	PEGASUS	**THY**	**ONURAIR**
PEGASUS	(1, 1, 1)	(1/3, 2/5, 1/2)	(1/2, 2/3, 1)
THY	(2, 5/2, 3)	(1, 1, 1)	(2, 5/2, 3)
ONURAIR	(1, 3/2, 2)	(1/3, 2/5, 1/2)	(1, 1, 1)

From Table 5.28

$S_{PEGASUS}$ = (1.83, 2.07, 2.5) * (1/13, 1/10.97, 1/13) = (0.14, 0.18, 0.27)

S_{THY} = (5, 6, 7) * (1/13, 1/10.97, 1/13) = (0.38, 0.54, 0.76)

$S_{ONURAIR}$ = (2.33, 2.9, 3.5) * (1/13, 1/10.97, 1/13) = (0.17, 0.26, 0.38)

By use of these vectors,

$V(S_{PEGASUS} \geq S_{THY}) = 1.00$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 1.00$

$V(S_{THY} \geq S_{PEGASUS}) = 0$

$V(S_{THY} \geq S_{ONURAIR}) = 0$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 0.55$

$V(S_{ONURAIR} \geq S_{THY}) = 1.00$ are obtained.

So that, the weight vector from Table 5.28 is computed as $W_{RCA} = (0.64, 0, 0.35)^T$

Table 5.29 Evaluating of the airline firms in comparison with return on fixed assets (RFA)

	PEGASUS	**THY**	**ONURAIR**
PEGASUS	(1, 1, 1)	(1, 3/2, 2)	(1/2, 2/3, 1)
THY	(1/2, 2/3, 1)	(1, 1, 1)	(2/5, 1/2, 2/3)
ONURAIR	(1, 3/2, 2)	(3/2, 2, 5/2)	(1, 1, 1)

From Table 5.29

$S_{PEGASUS}$ = (2.5, 3.17, 4) * (1/12.17, 1/9.83, 1/7.9) = (0.2, 0.32, 0.5)

S_{THY} = (1.9, 2.17, 2.67) * (1/12.17, 1/9.83, 1/7.9) = (0.15, 0.22, 0.33)

$S_{ONURAIR}$ = (3.5, 4.5, 5.5) * (1/12.17, 1/9.83, 1/7.9) = (0.28, 0.45, 0.69)

By use of these vectors, we obtained

$V(S_{PEGASUS} \geq S_{THY}) = 0.56$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 1.00$

$V(S_{THY} \geq S_{PEGASUS}) = 1.00$

$V(S_{THY} \geq S_{ONURAIR}) = 1.00$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 0.62$

$V(S_{ONURAIR} \geq S_{THY}) = 0.17$

So that, the weight vector from Table 5.29 is computed as $W_{RFA} = (0.32, 0.57, 0.09)^T$

Table 5.30 Evaluating of the airline firms in comparison with return on total assets (RTA)

	PEGASUS	**THY**	**ONURAIR**
PEGASUS	(1, 1, 1)	(1/2, 1, 3/2)	(1/2, 2/3, 1)
THY	(2/3, 1, 2)	(1, 1, 1)	(1/2, 2/3, 1)
ONURAIR	(1, 3/2, 2)	(1, 3/2, 2)	(1, 1, 1)

From Table 5.30

$S_{PEGASUS}$ = (2,2.67, 3.5) * (1/12.5, 1/9.33, 1/7.17) = (0.16, 0.28, 0.48)

S_{THY} = (2.17, 2.67, 4) * (1/12.5, 1/9.33, 1/7.17) = (0.17, 0.28, 0.55)

$S_{ONURAIR}$ = (3, 4, 5) * (1/12.5, 1/9.33, 1/7.17) = (0.24, 0.42, 0.69)

By use of these vectors, we obtained

$V(S_{PEGASUS} \geq S_{THY}) = 1.00$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 1.00$

$V(S_{THY} \geq S_{PEGASUS}) = 1.00$

$V(S_{THY} \geq S_{ONURAIR}) = 1.00$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 0.63$

$V(S_{ONURAIR} \geq S_{THY}) = 0.68$

So that, the weight vector from Table 5.30 is computed as $W_{RTA} = (0.38, 0.38, 0.23)^T$

Table 5.31 Evaluating of the airline firms in comparison with return on stockholders' equity (RSE)

	PEGASUS	THY	ONURAIR
PEGASUS	(1, 1, 1)	(2/5, 1/2, 2/3)	(2/5, 1/2, 2/3)
THY	(3/2, 2, 5/2)	(1, 1, 1)	(1, 3/2, 2)
ONURAIR	(3/2, 2, 5/2)	(1/2, 2/3, 1)	(1, 1, 1)

From Table 5.31

$S_{PEGASUS}$ = (1.8, 2, 2.33) * (1/12.33, 1/10.17, 1/8.3) = (0.14, 0.19, 0.28)

S_{THY} = (3.5, 4.5, 5.5) * (1/12.33, 1/10.17, 1/8.3) = (0.28, 0.44, 0.66)

$S_{ONURAIR}$ = (3, 3.67, 4.5) * (1/12.33, 1/10.17, 1/8.3) = (0.24, 0.36, 0.54)

By use of these vectors,

$V(S_{PEGASUS} \geq S_{THY}) = 1.00$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 1.00$

$V(S_{THY} \geq S_{PEGASUS}) = 0$

$V(S_{THY} \geq S_{ONURAIR}) = 1.00$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 0.19$

$V(S_{ONURAIR} \geq S_{THY}) = 1.00$ are obtained.

So that, the weight vector from Table 5.31 is computed as $W_{RSE} = (0.84, 0, 0.15)^T$

Table 5.32 Evaluating of the airline firms in comparison with return on operation profit to capital (ROPC)

	PEGASUS	THY	ONURAIR
PEGASUS	(1, 1, 1)	(2/5, 1/2, 2/3)	(2/7, 1/3, 2/5)
THY	(3/2, 2, 5/2)	(1, 1, 1)	(2/7, 1/3, 2/5)
ONURAIR	(5/2, 3, 7/2)	(5/2, 3, 7/2)	(1, 1, 1)

From Table 5.32

$S_{PEGASUS}$ = (1.62, 1.73, 1.9) * (1/14.3, 1/12.57, 1/10.9) = (0.11, 0.13, 0.17)

S_{THY} = (3.29, 3.83, 4.4) * (1/14.3, 1/12.57, 1/10.9) = (0.22, 0.3, 0.4)

$S_{ONURAIR}$ = (6, 7, 8) * (1/14.3, 1/12.57, 1/10.9) = (0.41, 0.55, 0.73)

By use of these vectors, we obtained

$V(S_{PEGASUS} \geq S_{THY}) = 1.00$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 1.00$

$V(S_{THY} \geq S_{PEGASUS}) = 0$

$V(S_{THY} \geq S_{ONURAIR}) = 1.00$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 0$

$V(S_{ONURAIR} \geq S_{THY}) = 0$

So that, the weight vector from Table 5.32 is computed as $W_{ROPC} = (1.00, 0, 0)^T$

Table 5.33 Evaluating of the airline firms in comparison with return on income before tax to capital (RIBTC)

	PEGASUS	THY	ONURAIR
PEGASUS	(1, 1, 1)	(2/5, 1/2, 2/3)	(2/7, 1/3, 2/5)
THY	(3/2, 2, 5/2)	(1, 1, 1)	(2/7, 1/3, 2/5)
ONURAIR	(5/2, 3, 7/2)	(5/2, 3, 7/2)	(1, 1, 1)

From Table 5.33

$S_{PEGASUS}$ = (1.69, 1.83, 2.07) * (1/13.97, 1/12.17, 1/10.47) = (0.12, 0.15, 0.19)

S_{THY} = (2.79, 3.33, 3.9) * (1/13.97, 1/12.17, 1/10.47) = (0.19, 0.27, 0.37)

$S_{ONURAIR}$ = (0.42, 0.57, 0.76) * (1/13.97, 1/12.17, 1/10.47) = (0.42, 0.57, 0.76)

By use of these vectors, we obtained

$V(S_{PEGASUS} \geq S_{THY}) = 1.00$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 1.00$

$V(S_{THY} \geq S_{PEGASUS}) = 0$

$V(S_{THY} \geq S_{ONURAIR}) = 1.00$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 0$

$V(S_{ONURAIR} \geq S_{THY}) = 0$

So that, the weight vector from Table 5.33 is computed as $W_{ROPC} = (1.00, 0, 0)^T$

Table 5.34 Evaluating of the airline firms in comparison with current assets turnover (CAT)

	PEGASUS	THY	ONURAIR
PEGASUS	(1, 1, 1)	(2/5, 1/2, 2/3)	(2/7, 1/3, 2/5)
THY	(3/2, 2, 5/2)	(1, 1, 1)	(2/7, 1/3, 2/5)
ONURAIR	(5/2, 3, 7/2)	(5/2, 3, 7/2)	(1, 1, 1)

From Table 5.34

$S_{PEGASUS}$ = (1.69, 1.83, 2.07) * (1/13.97, 1/12.17, 1/10.47) = (0.12, 0.15, 0.19)

S_{THY} = (2.79, 3.33, 3.9) * (1/13.97, 1/12.17, 1/10.47) = (0.19, 0.27, 0.37)

$S_{ONURAIR}$ = (0.42, 0.57, 0.76) * (1/13.97, 1/12.17, 1/10.47) = (0.42, 0.57, 0.76)

By use of these vectors, we obtained

$V(S_{PEGASUS} \geq S_{THY}) = 1.00$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 1.00$

$V(S_{THY} \geq S_{PEGASUS}) = 0$

$V(S_{THY} \geq S_{ONURAIR}) = 1.00$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 0$

$V(S_{ONURAIR} \geq S_{THY}) = 0$

So that, the weight vector from Table 5.34 is computed as $W_{ROPC} = (1.00, 0, 0)^T$

Table 5.35 Evaluating of the airline firms in comparison with fixed assets turnover (FAT)

	PEGASUS	**THY**	**ONURAIR**
PEGASUS	(1, 1, 1)	(3/2, 2, 5/2)	(2/7, 1/3, 2/5)
THY	(2/5, 1/2, 2/3)	(1, 1, 1)	(2/7, 1/3, 2/5)
ONURAIR	(5/2, 3, 7/2)	(5/2, 3, 7/2)	(1, 1, 1)

From Table 5.35

$S_{PEGASUS}$ = (2.79, 3.33, 3.9) * (1/13.97, 1/12.17, 1/10.47) = (0.19, 0.27, 0.37)

S_{THY} = (1.69, 1.83, 2.07) * (1/13.97, 1/12.17, 1/10.47) = (0.12, 0.15, 0.19)

$S_{ONURAIR}$ = (6, 7, 8) * (1/13.97, 1/12.17, 1/10.47) = (0.42, 0.57, 0.76)

By use of these vectors, we obtained

$V(S_{PEGASUS} \geq S_{THY}) = 0$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 1.00$

$V(S_{THY} \geq S_{PEGASUS}) = 1.00$

$V(S_{THY} \geq S_{ONURAIR}) = 1.00$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 0$

$V(S_{ONURAIR} \geq S_{THY}) = 0$

So that, the weight vector from Table 5.35 is computed as $W_{FAT} = (0, 1, 0)^T$

Table 5.36 Evaluating of the airline firms in comparison with total assets turnover (TAT)

	PEGASUS	**THY**	**ONURAIR**
PEGASUS	(1, 1, 1)	(1, 3/2, 2)	(2/7, 1/3, 2/5)
THY	(1/2, 2/3, 1)	(1, 1, 1)	(2/7, 1/3, 2/5)
ONURAIR	(5/2, 3, 7/2)	(5/2, 3, 7/2)	(1, 1, 1)

From Table 5.36

$S_{PEGASUS}$ = (2.29, 2.83, 3.4) * (1/13.8, 1/11.83, 1/10.07) = (0.16, 0.23, 0.33)

S_{THY} = (1.79, 2, 2.4) * (1/13.8, 1/11.83, 1/10.07) = (0.12, 0.16, 0.23)

$S_{ONURAIR}$ = (6, 7, 8) * (1/13.8, 1/11.83, 1/10.07) = (0.43, 0.59, 0.79)

By use of these vectors, we obtained

$V(S_{PEGASUS} \geq S_{THY}) = 0.5$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 1.00$

$V(S_{THY} \geq S_{PEGASUS}) = 1.00$

$V(S_{THY} \geq S_{ONURAIR}) = 1.00$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 0$

$V(S_{ONURAIR} \geq S_{THY}) = 0$

So that, the weight vector from Table 5.36 is computed as $W_{TAT} = (0.33, 0.66, 0)^T$

Table 5.37 Evaluating of the airline firms in comparison with stockholders' equity (SE)

	PEGASUS	**THY**	**ONURAIR**
PEGASUS	(1, 1, 1)	(1/2, 2/3, 1)	(2/7, 1/3, 2/5)
THY	(1, 3/2, 2)	(1, 1, 1)	(2/7, 1/3, 2/5)
ONURAIR	(5/2, 3, 7/2)	(5/2, 3, 7/2)	(1, 1, 1)

From Table 5.37

$S_{PEGASUS}$ = (1.79, 2, 2.4) * (1/13.8, 1/11.83, 1/10.07) = (0.12, 0.16, 0.23)

S_{THY} = (2.29, 2.83, 3.4) * (1/13.8, 1/11.83, 1/10.07) = (0.16, 0.23, 0.33)

$S_{ONURAIR}$ = (6, 7, 8) * (1/13.8, 1/11.83, 1/10.07) = (0.43, 0.59, 0.79)

By use of these vectors, we obtained

$V(S_{PEGASUS} \geq S_{THY}) = 1.00$

$V(S_{PEGASUS} \geq S_{ONURAIR}) = 1.00$

$V(S_{THY} \geq S_{PEGASUS}) = 0.5$

$V(S_{THY} \geq S_{ONURAIR}) = 1.00$

$V(S_{ONURAIR} \geq S_{PEGASUS}) = 0$

$V(S_{ONURAIR} \geq S_{THY}) = 0$

So that, the weight vector from Table 5.37 is computed as $W_{SE} = (0.66, 0.33, 0)^T$

Table 5.38 Summary combination of priority weights

Sub attributes of short term liquidation				
	CR	EFR	ER	Alternative priority weight
Weight	0,5	0,25	0,25	
Alternative				
PEGASUS	0,82	0,97	0,5	0,7775
THY	0	0	0,25	0,0625
ONURAIR	0,17	0,02	0,25	0,1525

Sub attributes of long term solvency				
	FLTR	DR	EDR	Alternative priority weight
Weight	0,68	0,31	0	
Alternative				
PEGASUS	0,38	1	1	0,5684
THY	0,38	0	0	0,2584
ONURAIR	0,23	0	0	0,1564

Sub attributes of profitability						
	OCR	GPR	OPR	IBTR	NIR	Alternative priority weight
Weight	0,49	0,35	0,08	0,06	0	
Alternative						
PEGASUS	0,36	1	0,74	0,55	0,39	0,6186
THY	0,31	0	0,25	0,09	0,21	0,1773
ONURAIR	0,31	0	0	0,34	0,39	0,1723

Sub attributes of debts turnover					
	CLT	LTLT	TLT	IER	Alternative priority weight
Weight	0,5	0	0	0,5	
Alternative					
PEGASUS	0,5	0,4	0,5	0,5	0,5
THY	0	0,2	0	0,5	0,25
ONURAIR	0,5	0,4	0,5	0	0,25

Sub attributes of return of investment							
	RCA	RFA	RTA	RSE	ROPC	RIBTC	Alternative priority weight
Weight	0,17	0,16	0,15	0,17	0,17	0,14	
Alternative							
PEGASUS	0,6	0,39	0,33	0,49	0,54	0,48	0,4562
THY	0,4	0,21	0,33	0,28	0,22	0,25	0,2711
ONURAIR	0	0,39	0,33	0,21	0,22	0,25	0,22

Sub attributes of assets and stockholder's turnover					
	CAT	FAT	TAT	SE	Alternative priority weight
Weight	0,43	0,12	0	0,43	
Alternative					
PEGASUS	0,48	0,5	0,4	0,42	0,447
THY	0,25	0	0,2	0,28	0,2279
ONURAIR	0,25	0,5	0,4	0,28	0,2879

Main attributes of the goal							
	STL	LTS	PF	DT	RI	AST	Alternative priority weight
Weight	0,23	0,25	0,27	0,18	0,05	0,09	
Alternative							
PEGASUS	0	0,08	0,13	0,01	0,7	0,19	0,109
THY	0,45	0,55	0,4	0,98	0,38	0,78	0,6146
ONURAIR	0,11	0,34	0,42	0	0,21	0	0,2342

THY is selected as the company with the best financial performance.

Chapter 6

Conclusion

This thesis focuses on evaluating financial performance in Turkish aviation by use of Fuzzy Analytic Hierarchy Process (FAHP) method. In this research, we consider the market share and we selected three firms with the largest market share as THY, Pegasus and Onurair.

At this study, Fuzzy Analytic Hierarchy Process approach is presented to determine the airline company with the optimum financial performance in Turkey. In the approach, we used triangular fuzzy numbers. The objective of this study is to define all the main criteria that should have impact on financial performance decision.

The reason of the choice of Fuzzy Analytic Hierarchy Process (FAHP) method, we had the balance sheet and income statements of THY and Pegasus but we had no information about Onurair. The FAHP approach handled at this work and the approach is proved to be straight forward. By use of this approach other existing decision making techniques are compared. By use of the FAHP does not include burdensome mathematical operations and it usually uses for solving practical problems of multi attribute decision making. The FAHP provides to take human thinking's vagueness ways and for solving multi attribute decision making problems effectively.

After developing the model and applying the method, THY was selected as the company best financial performance.

For following studies, the model can be extended.

References

Ayağ, Z., Özdemir, R.G., "*A Fuzzy AHP Approach to Evaluating Machine Tool Alternatives*", Journal of Intelligent Manufacturing, 17, 179-190, (2006)

Li, Y., Sha, R., Li, L., Wang, J., "*A AHP(Analytic Hierarchy Process) Strategic Decision Model Study of Chinese Retail Industry Green Supply Chain*", IEEE, 3, (2011)

Kasperczyk, N., Knickel, K., "The Analytic Hierarchy Process (AHP)"

http://www.palgrave-journals.com/jba/journal/v4/n3/fig_tab/jba200834f4.html

Goh, H.H., Kok, B.C., "*Application of Analytic Hierarchy Process (AHP) in Load Shedding Scheme for Electrical Power System*", 1

Amyot, N., Hudon, C., Bélec, M., Lamarre, L., Nguyen, N.D., "Probabilistic Assessment of Generator Failure Using the Analytic Hierarchy Process (AHP)", 1-3

Chatterjee, D., Mukherjee, B., "*Study Of Fuzzy-Ahp Model To Search The Criterion In The Evaluation Of The Best Technical Institutions: A Case Study*", International Journal of Engineering Science and Technology Vol. 2(7), 2499-2503, (2010)

Vahidniaa, M.H., Alesheikhb, A., Alimohammadic, A., Bassirid, A., "*Fuzzy Analytical Hierarchy Process In GIS Application*", Commission II, WG II/4, 593-595

Tiryaki, F., Ahlatcioglu, B., "*Fuzzy portfolio selection using fuzzy analytic hierarchy process*", Information Sciences 179, 53–69, (2009) http://www.readyratios.com

http://www.accounting4management.com/debtors_or_receivable_turnover_ratio.htm#wWAzHjMJVeDCQmMC.99

Kulak, O., Kahraman, C., "*Fuzzy multi-attribute selection among transportation companies using axiomatic design and analytic hierarchy process*", Information Sciences 170, 191–210, (2005)

Kahraman, C., Cebeci, U., Ruan, D., "*Multi-attribute comparison ofcatering service companies using fuzzy AHP: The case of Turkey*", Int. J. Production Economics 87, 171–184, (2004)

Kaptanoğlu, D., Ozok, A.F., "*Akademik performans değerlendirmesi için bir bulanık model*", itüdergisi/*d* mühendislik, Cilt:5, Sayı:1, Kısım:2, 193-204, (2006)

Yao, J.S., Shih, T.S., *"Fuzzy Revenue for Fuzzy Demand Quantity Based on Interval-Valued Fuzzy Sets"*, Computers & Operation Research 29 *(2002)*

L.A.Zadeh, "*Fuzzy Sets*", Information and Control, 8, 338-353, (1965)

VanLaarhoven, P.J.M., Pedrycz, W., "*A Fuzzy Extension of Saaty's Priority Theory*", Fuzzy Sets and Systems, 11, 229-241, (1983)

Kahraman, C., Cebeci, U., Ulukan, Z., "*Multi-criteria Supplier Selection Using Fuzzy AHP*", Logistics Information Management, 16, 382–394, (2003)

Saaty, T., Vargas, L. G. , *"Models, Methods & Applications of the Analytic Hierarchy Process"*, Kluwer's International Series, London, (2001)

Saaty, T.L., "*The Analytic Hierarchy Process"*, Mc Graw-Hill, New York, (1980) Chang, D.Y., "*Applications of the Extent Analysis Method on Fuzzy AHP*", European Journal of Operational Research, 95, 649-655, (1996)

Akoz, O., & Petrovic, D., "*A fuzzy goal programming method with imprecise goal hierarchy*", European Journal of Operational Research, (2006)

Arıkan, F., Güngör, Z., "*An Application of fuzzy goal programming to a multiobjective project network problem*", Fuzzy Sets and Systems, 119, 49-58, (2001)

Kahraman, C., "*Fuzzy Multi-Criteria Decision-Making Theory and Applications with Recents Developments*", Springer, 10-16, (2008)

Triantaphyllou, E., "*Multi-Criteria Decision Making Methods: A Comparative Study*", Kluwer Academic Publishers, Volume 44, 3-4

www.turkishairlines.com.tr
www.pegasus.com.tr
www.onurair.com.tr
http://www.ulastirmahaber.com

Curriculum Vitae

Sinem GÜREL was born on 8 July 1985, in Istanbul. She received her BS degree in Industrial Engineering in 2007 and M.S. degree in 2012 in Industrial Engineering both from Kadir University.

Thesis

- Title of Graudate Thesis: "*APPLICATION OF ANALYTIC NETWORK PROCESS (ANP) FOR SUPPLIER SELECTION IN TURKISH AUTOMOTIVE INDUSTRY*" , JUNE, 2007.

  Project Supervisor: Assoc. Prof. Dr. Zeki AYAĞ

- Title of Master's Thesis: "*A FUZZY AHP APPROACH FOR FINANCIAL PERFORMANCE EVALUATION OF AIRLINE COMPANIES*", OCTOBER 2012.

  Project Supervisor: Assoc. Prof. Dr. Zeki AYAĞ