MALAVIYANATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF MECHANICAL ENGINEERING
Jawahar Lal Nehru Marg, Jaipur-302017(Rajasthan)

CERTIFICATE

This is to certify that the dissertation report on the topic "**PROJECT SELCTION USING HYBRID AHP AND PROMETHEE"** prepared by **SHRIKANT BANSAL (ID: 2013PIE5196)** in the partial fulfillment for the award of degree of Master of Technology in **Industrial Engineering** of Malaviya National Institute of Technology Jaipur is a bonafide compilation of the candidate's work based on published literature in the topic.

DR. M.L.MITTAL

Associate Professor

Place: Jaipur — Department of Mechanical Engineering

Date: 27 June 2016 — MNIT Jaipur

MALAVIYANATIONAL INSTITUTE OF TECHNOLOGY JAIPUR
DEPARTMENT OF MECHANICAL ENGINEERING
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CANDIDATE'S DECLARATION

I hereby certify that work which is being presented in the dissertation entitled "**PROJECT SELCTION USING HYBRID AHP AND PROMETHEE"** in the partial fulfillment of requirement for award of the degree of Master of Technology (M. Tech.) in Industrial Engineering and submitted in Department of Mechanical Engineering of Malaviya National Institute of Technology Jaipur is an authentic record of my own work carried out during a period from July 2015 to June 2016 under the supervision of **Dr. M.L.Mittal** , Department of Mechanical Engineering, Malaviya National Institute of Technology Jaipur.

The matter presented in this dissertation embodies the result my own work and studies carried out and has not been submitted anywhere else.

(SHRIKANT BANSAL)

Place: Jaipur **M. Tech. (IE)**

Date: **ID:** 2013PIE5196

ACKNOWLEDGEMENT

I would like to dedicate my genuine and heartfelt gratitude to my supervisor **Dr. M.L.MITTAL**, Associate Professor, Department of Mechanical Engineering, M.N.I.T. Jaipur who guided me with his dedicated attention, expertise and knowledge throughout the process of this dissertation. I am highly thankful for his valuable guidance, his commitment, timely advice and constant support at each and every step in completion of the study. His scientific and analytical approach, wide knowledge and motivating remarks really helped me at every need of this work.

I would like to thank to **Dr. G. S.Dangayach**, Professor and Head of Department, and **Dr. Gunjan Soni**, Assistant Professor and P.G. Coordinator, for keeping healthy research environment within the department.

I am also thankful to **Dr. G. Agarwal,** Professor; **Dr. A. P. S. Rathore**, Professor, **Dr. Rakesh Jain** Professor, **Dr. A.Bhardwaj**, Professor and **Dr. M. L.Meena**, Assistant Professor for providing means and supports to pursue this dissertation work.

I am also indebted to **Mr. Jayant K. Purohit** and **Mr. Manish Kumar** for helping and supporting me whenever required.

I am also thanking our colleagues, research scholars and friends for their helpful suggestions and encouragement.

SHRIKANT BANSAL
(2013PIE5196)

ABSTRACT

The art and science of selecting projects is one that organizations take extremely seriously. Firms in a variety of industries have developed highly sophisticated methods for project screening and selection to ensure that the projects they choose to fund offer the best promise of success. As part of this screening process, organizations often evolve their own particular methods, based on technical concerns, available data, and corporate culture and preferences. Firms are literally bombarded with opportunities, but of course, no organization enjoys infinite resources to be able to pursue every opportunity that presents itself. Choices must be made, and to best ensure that they select the most viable projects, many managers develop priority systems guidelines for balancing the opportunities and costs entailed by each alternative.

The main objective is to select/rank the various project alternatives. The second objective of this thesis is to suggest a hybrid approach for project selection. The suggested approach is the combination of AHP and PROMETHEE comprising basic features of the two techniques. Therefore, this research has deployed a simple methodology called PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluations). A ranked value judgment on quantitative criteria and the method is used by combining the Analytic Hierarchy Process (AHP) for determining the relative importance of criteria for information system project selection.

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On

“PROJECT SELCTION USING HYBRID AHP AND PROMETHEE”

By

SHRIKANT BANSAL

(ID: 2013PIE5196)

Supervisor

DR. M.L.MITTAL

Department of Mechanical Engineering

Submitted in fulfilment of the requirement for the award of the degree of

MASTER OF TECHNOLOGY

IN

INDUSTRIAL ENGINEERING

DEPARTMENT OF MECHANICAL ENGINEERING

MALAVIYA NATIONAL INSTITUTE OF TECHNOLOGY JAIPUR

JUNE 2016

CHAPTER 1

INTRODUCTION

1.1 Background

The project is an attempt in which human (or machine), material and financial resources are organized in a novel way, to undertake a unique scope of work, or given specification, within constraints of cost and time, so as to deliver beneficial change by quantitative and qualitative objectives.

Project selection is a critical decision in many organizations. It is an essential management function that is compulsory to ensure business survival (Moselhi et. Al , 1993). Ideally, projects and programs that are selected to be undertaken are consistent with strategic objectives for the organization The project will provide value for money and return on investment; The project will be effectively resourced and selected; The project will not compete with general operations for resources and not restrict the ability of operations to provide income to the organization; The project will match the capacity and capability of the organization t and The project will produce outputs that are cheerfully accepted by end users and customers.

There is a wide variety of project selection problems like construction site selection, R & D project selection, information system project selection, investment decisions, information system project selection problems etc. (Jeffrey K. Pinto. 2010). Decision makers often face the problem of considering a large number of alternatives, and selecting one based on a number of contradictory criteria. It must be noted that due to the number of selection criterion while choosing the best alternative, and decision makers have to consider all of these selection criteria. A project selection model that creates useful information for project selections in a timely and useful fashion at an acceptable cost which can help as a valued tool for helping the organization to make optimal choices among numerous alternatives is required(Khorramshahgol et. Al.1988)

1.2 Solution Approaches of Project Selection

There is a wide range of methods for project selection, which have been developed to ensure that the selected projects give the highest success. Like

A) **Checklist Model** is an artless method of project screening and selection which involves developing a checklist**,** or a list of criteria that relate to our choice of projects, and then applying them to different possible projects.so we would screen each possible project against these criteria and select the project that best satisfies them.

B) **Scoring Model** is the simplified scoring model; each criterion is ranked according to its relative importance. The choice of projects will thus reflect the desire to maximize the impact of certain criteria on our decision by assigning specific weight to each criterion.

C) **Portfolio Matrices** (‘‘bubble diagrams") are widespread for displaying parameter values on three or four project dimensions. For example, the probability of success can be plotted against net present value for available projects, with the size of the bubble used on the chart representing expected ROI. Even though bubble diagrams are popular for graphical demonstrations and comparisons, they have small theoretical or empirical support, and they may lead decision makers to overlook profit maximization (Armstrong and Brodie, 1994).

D) **Financial Models** are another significant series of models relies on financial analysis to make project selection decisions. There are three common financial models: discounted cash flow analysis, NPV (net present value), and IRR (internal rate of return). These are not the only financial methods for assessing project alternatives, but they are among the more popular. Financial models are all predicated on the time value of money principle.

E) **Optimization Models** Optimization models select the best alternative from the list of projects that offers maximum benefit. These models are mostly based on mathematical programming and support the optimization process considering project interactions like resource dependencies and constraints, market and technical interactions, or program considerations Some models support sensitivity analysis, but they are not to be used widely in practice. Possible reasons for disuse comprise the need to collect large amounts of input data, they are incapable to include model complexities and risk considerations together.

1.3 Multi-attribute decision making (MADM) approach

In recent year, the awareness about consideration of other criteria like competitive advantages strategic match, impact on exiting environment is increased rather than considering only the financial criteria (Stewart et al. 2002). Therefore, the problems of Multi-attribute decision making (MADM) are come across very often within the organizations. various methodologies have been developed to solve such problems since decades. The topic covers a wide variety of problems, maximum time, the methodologies developed focused on an explicit property of the problem, that means the methodologies are specific to a problem and it is difficult to tackle different scenarios. There are number of MADM techniques are identified for project selection like MAUT,AHP, Fuzzy Set Theories, CBR, DEA(Data Envelopment Analysis), SMART(Simple Multi Attribute Rating Technique), ELECTRE, PROMETHEE,SAW (Simple Additive Weighting), and TOPSIS Method for Order of Preference by Similarity to Ideal Solution. Other than these various combinations of the above mention tech nique are also used by researchers.

1.4 Objective and scope of study

The main objective is to select/rank the various project alternatives. Although AHP (analytical hierarchy process) is widely used technique for this purpose. The other technique which is suitable for the ranking/selection is PROMETHEE but both the method has their advantages and limitations. The second objective of this thesis is to suggest a hybrid approach for project selection. The suggested approach is the combination of both the approaches comprising basic features of the two techniques.

The base of suggested methodology is the renowned outranking technique called Promethee II. There is a drawback of the methods of Promethee family that they don’t propose any methods for identification of the relative weight of the criteria , which has an vital impact on the final ranking in MADM problem. In this study for the calculation of the criteria weights , Analytical Hierarchy Process (AHP) technique is proposed.

The PROMETHEE technique can efficiently treat primarily criteria which are quantitative in nature. Still, here exist various difficulties for the situation of qualitative criteria . For a qualitative criterion ; a ranked value judgment on a fuzzy scale is opted in the study. The value of the qualitative criteria first decided as linguistic scale, then changed into equivalent fuzzy number and finally transformed into the crisp values. A logicel approach based on the work of Chen and Hwang (1992) is represented by Rao (2010).

1.5 Outline of dissertation

The thesis is organized into five chapters.

The current chapter 1 introduces the thesis and emphasizes the need for conducting this research work. This chapter also identifies the aim and objective of the study.

Chapter 2 presents a critical review of past work on project selection techniques. The literature review basically presents the technique which is in practice for MADM with consideration of criteria for project selection.

Chapter 3 consists of the theoretical background of hybrid AHP-PROMETHEE. The procedure for both Promethee and AHP is described in this chapter along with fuzzy mathematics.

Chapter 4 is case study which is done to practice the suggested

Chapter 5 conclude the results obtained in the previous chapter

Chapter 6 shows scope for future work.

CHAPTER 2

LITERATURE REVIEW

One of the most difficult problems while selecting information system (IS) or/ information technology (IT) project is to estimate benefit. Using a limited idea of financial gains can have an adverse effect on this exploration. In addition to the difficulty of measurement, amongst the main aims of an IS project is that there are aims other than financial issues. For example, satisfactory consideration is that a project should support strategic goals of the organization (Doherty et al., 1999).

Taking above consideration into account certain studies have given different results for the effectiveness of IS investments. As stated by (Zopounidis ,1999), the financial analysis should be introduced into a general framework, and therefore, this is one of the criteria considered in decision making, so that the relative significance of each criterion can be considered. The traditional methodologies to making a financial assessment seek to fulfill only the management's aims. (Milis et al 2004) stated that an IS project is usually a group decision, and each decision maker (DM) has a group of criteria, which each DM assesses in line with the given importance by him. It is required to have the support of these decision makers, which can be reached by integrating the serious factors that may affect them into the decision-making process.

In the environment of distinct MCDM problems, several methodologies have been suggested, utilizing many empirical and numerical methods.

Multi-Criteria attribute Making (MCDM) methods are gaining popularity in alternative selection. The methods offer solutions to the problems involving multiple and conflicting objectives. Numerous methods based on weighted averages, outranking, priority setting, fuzzy principles and the combination of these are employed for decisions in various areas. A review of published literature is presented here to consider the applicability of these methods.

Multi-Criteria decision Making is a famous branch of decision making. MCDM is a branch of a common class of Operations Research (OR) models which deals with decision problems under the influence of a number of decision criteria. MCDM is further divided into multi-attribute decision making (MADM) and multi objective decision making (MODM).(Climaco J,1997)

The Weighted sum method (WSM) is the generally used approach, particularly in single dimensional problems. The difficulty with WSM appears when it is applied to multi-dimensional decision-making problems in combining dissimilar dimensions, and subsequently dissimilar units than the additive utility assumption are violated (Soolen J. 2003). There is another technique called weighted product method (WPM). The WPM is similar to WSM. The key difference with WSM is that in its place of addition there is multiplication in WPM. (Chang et. al, 2001)

TOPSIS is “an approach to discover the closest alternative to the ideal solution and furthermost to the negative ideal solution in a multi-dimensional computing space” (Qin *et al.*, 2008). TOPSIS has various advantages. Due to its simplicity It is easy to use and it is also programmable. The number of steps does not change irrespective of the number of attributes.
The disadvantage of TOPSIS is that it uses Euclidean Distance which does not consider the correlation of attributes. There are difficulties to weight attributes and keeping a consistency of judgment, particularly with additional attributes.

The multiple attribute decision making (MADM) techniques VIKOR and TOPSIS are based on an aggregating function representing ‘‘closeness to the ideal’’, which invented in the compromise programming method. In TOPSIS vector normalization and in VIKOR linear normalization is used to remove the units of criterion functions. The VIKOR method of compromise ranking defines a compromise solution, providing a maximum ‘‘group utility’’ for the ‘‘majority’’ and a minimum of an individual regret for the ‘‘opponent’’. The TOPSIS method determines a solution with the shortest distance to the ideal solution and the greatest distance from the negative-ideal solution, but it does not consider the relative importance of these distances. A comparative analysis of these two methods is illustrated with a numerical example, showing their similarity and some differences.(Opricovic et . al. 2004)

Analytical Hierarchy Process (AHP), developed by Saaty (1980), is one of the widespread techniques used by the practitioners and researchers. It is a pairwise comparison method, which can formulate the complex problems in a uni-directional hierarchal structure supposing that there is no interdependency between the levels. It is a comparatively simple and intuitive method, which permits the conversion of qualitative values into the quantitative value.

There is a number of example of the AHP applications in literature found like Jain et al. (1996) uses simply AHP for a new venture selection problem, in these both qualitative and quantitative criteria are easily handled. Khalil et al. (2002) used AHP to select the appropriate project delivery method. Kwak et al. (1997) used AHP to assign proper weights in a 0-1 goal programming application. Furthermore, Gabriel et al. (2005) used AHP and Monte Carlo simulation for uncertainty in data. Tavana (2003) combined group decision making with AHP for assessing and ranking advanced technology projects at NASA. Pokher et al. (2004) examined the application of AHP for sustainable energy policy decisions.

To handle the non-linear hierarchies Saaty et al. (1986) reviewed AHP in their study . the Analytical Network Process (ANP) is developed by Saaty (1999) , which is a form of AHP. Using the advantageous properties of AHP, ANP can handle feedback and interdependence and represents the combined weights by using calculations for the super matrix phenomena. Ulutas (2005) suggested ANP for evaluating the alternative energy sources for a country. ANP is employed for R & D project selection by Meade et al. (2002) in their study. Shyur et al. (2005) employed ANP while developing a hybrid method for considering interdependency among criteria.

There are number of other techniques which are developed for the multi attribute decision purpose. Karasakal et al. (2005) suggested a technique which utilizes the “impact matrix” concept and the operation of matrix multiplication in order to achieve the combined weights of the criteria. Carlsson et al. (1994) presented interdependency concept into the MADM. They gave suggestions those are built for three types of relationships between criterion, naming conflict, support, and independency. They illustrated the technique with a numerical example. Later on, Östermark (1996) upgraded their technique.

Santhanam et al. (1994) used the Preemptive Goal Programming technique in their study; they formulated a multi criteria decision model for resolving an Information System project selection problem with interdependencies. Later Santhanam et al. (1995), they developed a nonlinear decision for Information System project selection.

Brans et. al. (1985) developed an another out ranking method for solving MADM problem that is Preference Ranking Organization METHod for Enrichment Evaluations (PROMETHEE) decision makers can practices these methods, for proposing either a partial ranking (Promethee I) or a complete ranking (Promethee II) of the available alternatives. Only a few parameters are asked to the decision maker(s), and they are easy to understand since they have an economic signification.

Brans et al. (1992) introduced Promethee V another outranking method in Promethee Family.
In Promethee V method, some constraints are integrated to the alternatives and the problem is transformed in to a 0-1 goal programming problem. This method is widely used for resource allocation and project ranking-selection problems. Promethee V is used for a water resources planning problem in the Middle East by Abu-Taleb et al. (1995). Mavrotas et al. (2006) upgraded the Promethee V application suggested by Abu-Taleb et al. (1995) for a project prioritization application.

Macharis et al. (2004) analyzed and discussed AHP and PROMETHEE methods together systematically in their study, They stated that operational synergies might be achieved by incorporating Promethee and fundamentals related with AHP. Specially, they argued that AHP could be used for determining weight in Promethee method, because in Promethee method there is no specific approach was suggested for determination of criteria weight. Wang et al. (2006) formed a hybrid method to rank choices by combining both AHP and Promethee II .for determination of the criteria, and to understand the configuration of the problem they used

AHP, for the final ranking they used Promethee II. Likewise, Babic et al. (1996) used AHP together with Promethee II to identify the priorities of the criteria in a multi criteria decision problem.

Wang et.al.(2007) presented a proposal of a decision model to support the IS outsourcing decision making; in this model they used two multiple criteria decision making techniques (AHP and PROMETHEE II), with additional dimensions (strategy, economics, resource, risk, management and quality). they have explained how the hybrid technique, in this case, AHP/PROMETHEE II, offers powerful tools to rank alternative information systems projects and to evaluate the relations between criteria. Their approach permits to deal with IS outsourcing project selection containing several contradictory performance criteria (quantitative as well qualitative). The proposed decision model can help practitioners choose and analyze factors and attributes easily. Because it is a quantitative process, the practitioners can make better decisions and obtain better results from outsourcing.

There are some other literatures available suggesting some more hybrid methodologies other than AHP-Promethee pair, which are developed by combinations of the specific and unique tools.i.e , Lee et al. (2001) recommended an integrated approach for IS project selection problems by solving interdependent multi-criteria using Delphi, ANP, and 0-1 GP. In their approach, ANP is used for determination of the criteria weight; meanwhile, interdependencies exist between the criteria. They also considered the Choice behavior of the decision maker that is another issue.

Multi-Attribute Utility Theory (MAUT) is used by Keeney and Raiffa (1976) to consider the choice behavior of the Decision makers for each criterion and they also evaluated the global utility of each alternative for the Decision makers by using additive utility function or multiplicative utility function. Then all alternatives are ranked according to the ultimate utilities. There is a problem with MAUT that it cannot deal with the decision maker’s actual choice behavior.

MAUT is an ordinary utility theory that can select the best course of action in a given MADM problem by assigning a utility to possible significance and computing the best possible utility (Mavrakis et al 2007). The advantage of MAUT is that it precedes taking uncertainty into account. MAUT can have a utility assigned to it, this is a quality of the method which is not accounted in many MADM techniques.

SMART is also an MADM technique which one is simplest forms of MAUT. It needs two assumptions that are utility independence and preferential independence. (Chen et. Al.2010). This method conveniently transforms importance of weights into definite numbers. Major advantages of SMART are its simplicity to use and it actually allows any type of weight assignment methods (i.e., absolute, relative, etc.) Lesser efforts are required by decision makers as compared to MAUT. It can handle data for each criterion very well. Disadvantage of SMART is that the procedure for determining the work is not appropriate for considering the complicated framework (Mavrakis et. Al. 2007)

Case-Based Reasoning **(**CBR) is an MADM technique that reclaims cases related to a problem from preexisted database of cases and suggests a solution to the decision-making problem based on the most similar cases (Daengdej et. Al., 1999). This method has its first advantages, that it needs a little effort in terms of obtaining additional data. CBR also involves a little maintenance because the database already exists and requires little sustentation. An another advantage is that it has other than most of the MADM methods, that it can improve with time, especially as many cases are updated to the database. It can also adapt to changes in the environment with its database of cases. CBR has a major drawback of sensitivity to inconsistency in data (Daengdej et.al. 1999).

Data Envelopment Analysis (DEA) uses a linear programming method to measure the relative efficiencies of alternatives (Thanassoulis, et. al. 2012). It compares the efficiencies of alternatives with relative to other alternatives, the alternative having maximum efficiency rated rank as 1, and all other alternatives rated rank as a fraction of 1. DEA has the capability of handling numerous inputs and outputs. Efficiency can be evaluated and calculated also in this. DEA can reveal the relationships that possibly will be in unknown in other methods. The disadvantage of DEA is that it does not treat imprecise data and it assumes that all data (input and output) are accurately known. But In real world application, this assumption cannot be true always" (Wang, et al.2005). DEA is used where efficiencies are needed to be compared. DEA is commonly used in medical, economic, utilities, agriculture, road safety, retail, and business problems.

ELimination and Choice Expressing REality (ELECTRE), is an outranking method based on concordance analysis. The main advantage of this method is to take uncertainty and vagueness into account. The process and outcomes may be hard to explain in easy terms, this is the main disadvantage with ELECTRE. The way of preferences which is incorporated doesn't display the lowermost performances under certain criteria. This outranking method does not directly identify the results and impacts which causes the weaknesses and strengths of the alternatives (Mavrakis et al., 2007)ELECTRE has been used in economics, energy, environmental, transportation, and water management problems.

The Decision Making Trial and Evaluation Laboratory (DEMATEL) method invented from the Geneva Research Centre, Battelle Memorial Institute (Gabus & Fontela, 1973; Fontela & Gabus, 1976). The DEMATEL method has been effectively applied in many arenas by analyzing complex political economic and scientific problems. DEMATEL is particularly practical and useful for visualizing the structure of complex causal relationships using digraphs or matrices. The DEMATEL method can change the relationship between the causes and effects of decision criteria into an understandable structural model. The DEMATEL approach has been explained by Ahmadi et al., (2015) in their study.

In the decision-making procedure, we usually encountered with uncertainty and ambiguity for calculating the weights of criteria and alternatives of the problem (Ghorabaee, 2016). The subjectivity of linguistic human observation is often ambiguous, inaccurate and inadequate in nature. Fuzzy logic (Zadeh, 1965; Kapoor and Tak, 2005) has the ability of dealing with such unpredictable evaluation information powerfully.

Sen et al. (2016) suggested there are several studies have been done by the developers to extend traditional decision making techniques and tools to function under fuzzy environment so as to deal with subjective valuation of information in the perspective of real world decision-making situation. Fuzzy numbers set can be combined with traditional MADM approaches to obtain the best suitable preference order when the data set is either subjective completely or a combination of objective and subjective input. They further analyze that Past researchers used fuzzy set hypothesis with traditional MADM methods resulting Fuzzy-VIKOR, Fuzzy-TOPSIS, Fuzzy-MOORA, Fuzzy-ELECTRE, Fuzzy- PROMETHEE, etc.

Rao et al. (2011) suggested an objective and subjective integrated multiple attribute decision-making technique for the problem of robot selection. The technique considered objective weights of the criteria as well as the subjective inclinations of the Decision Makers to decide the combined weight of importance of the criteria. The technique used fuzzy logic to convert the qualitative attributes into the quantitative ones.

Fuzzy sets have been functional in several areas. Scholars in the finance and accounting field have used fuzzy sets to improve guidelines for investment decisions (Korvin et al., 1995; Tanaka et al., 1976). Fuzzy-AHP has been used by Bayou et al., 2007 for the selection of the optimal mechanism for evolving accounting standard.

Cheung et al., 2001 suggested in their theory that Administrators have used fuzzy sets to assess the significance of construction disagreement of a construction project in order to take suitable action for correction. Chan et al., 2002 used fuzzy sets to select the proper process for quality improvement for evaluation purposes.

Tsourveloudis et. Al. (1998) Suggested A procedure for measuring manufacturing flexibility using fuzzy logic Wu et al. (2007) has joined fuzzy multilayered AHP with group decision-making process to pursue the harmony of experts. A fuzzy-MADM has been developed by Thomaidis et al. (2006) for assessment of information technology (IT) projects.

Numerous methods have been suggested to help organizations to create well IS project selection decisions. The present methodologies for IS project selection variety from single criteria cost-benefit analysis to multiple criteria scoring models and ranking methods, or subjective committee evaluation methods. (Lee2001).

Chen et. Al. 2009, state that the uncertainty includes benefits ,business goals, project risks and limitation of available resources, and they projected a multi attribute decision model based on fuzzy measurement. Each IS project has diverse benefits for consideration in the selection process. According to Mehrez et al. (1993),the characteristic associated with the cost of each project and the budget available to select them makes selecting an IS project a multi attribute selection problem.

A financial benefit has been considered as prime objective for selecting IT/IS project (Ballantine et. Al. 1996) but in recent years the decision makers become more aware about other objective like, competitive advantages, strategic match, market share and future growth. Selection of IT/IS project is depends on that which project employs maximum business value with minimum level of risk. Though they are many criteria which are considered are as follow

1**. Risk** is the Factors that replicate the components of unpredictability to the organization.risk is further classifies as below

a) Technical risk: this occurs due to the development of new technologies or the technology which are not tested or used before.
b) Financial risk is risks which occurs due to the finance caused by investing in the project
c) Quality risks are the risks which affect the organization’s reputation due to the quality of the accomplished project.

2. Operational impact the impact of the project on internal operations of the firm which occurs

a) Due to training of employees if the new technology is to be used
b) Due to increase in workforce size
c) Due to Change in physical atmosphere of the organization

3. Strategic match is degree to which the project meets the corporate strategy, organizational aims.

4. Competitive impact includes the impact of project due to

a) Ability to increase potential market share
b) To get new business opportunity

5. Economic impact is the impact on organizations economics which is measured by various financial terms like economic return, ROI, and other business values.

CHAPTER 3
THEORETICAL BACKGROUND

3.1 Hybrid AHP-PROMETHEE

Brans et al. (1984) introduced The PROMETHEE method and it belongs to the category of outranking methods. Like all other outranking methods, PROMETHEE proceeds to a pairwise comparison of alternatives in each single criterion in order to determine partial binary relations denoting the strength of preference of an alternative a1 over alternative a2. In the evaluation table, the alternatives are evaluated on different criteria. The execution of PROMETHEE requires some additional types of information, namely:

- relative importance or the weights of the criteria considered, and
- decision maker preference function, for comparing the influence of all alternatives in terms of each criterion

It can be added here that the original PROMETHEE method can efficiently deal generally with quantitative criteria. For qualitative criteria, there exists some difficulty. In the situation of a qualitative criterion (i.e. quantitative value is not available); a fuzzy conversion scale is adopted for a ranked value judgment in this. By using fuzzy set theory, the value of the criteria can be first decided as linguistic terms, converted into corresponding fuzzy numbers and then changed to the crisp scores. In the present work, a five-point scale is considered for understanding and representation. Once a qualitative criterion is represented on a scale then the alternatives can be compared with each other on this criterion in the same manner as that for quantitative criteria

3.2 Preliminaries of fuzzy mathematics

Decision making is observed as a logical process, normally known to weaken the uncertainty and disbelief among the numbers of alternatives to make the best choice. To grasp any result, Decision Makers need to access the input response that is of two types: subjective information or objective information. Subjective information can be communicated or talked through normal language description. The objective information is a numerical dimension expressed in terms of numbers as an alternative of a normal language description. Objective information can be accessed simply with the help of conventional MCDM techniques; however, dealing with the subjective information is a relatively challenging assignment as this information does not recognize the explicit situation. Subjective information cannot be used until and unless they are transformed into some scientific values. So Fuzzy set theory provides a strict scientific system through which dicey information can be converted into an incorporated scale exactly.

Definition of fuzzy sets

Definition1. A fuzzy set Ã in a universe of discourse X is characterized by a membership function $\mu_{\tilde{A}}(x)$ which associates with each element x in X a real number in the interval [0, 1]. The function value $\mu_{\tilde{A}}(x)$is termed as the grade of membership of x in Ã.

Definition2. A fuzzy set Ã.in a universe of discourse X is convex if and only if:

$$(\lambda x1 + (1 - \lambda x2) \geq \min(\mu_{\tilde{A}}(x1), \mu_{\tilde{A}}(x2)) \qquad (3.2.1.1)$$

For all x1, x2 in X and all λ ∈ [0, 1], where “min” represents the minimum operator.

Definition3. The height of a fuzzy set is the largest membership grade attained by any element in that set. A fuzzy set Ã in the universe of discourse X is called normalized when the height of is equal to 1.

Definition4. Suppose, a positive triangular fuzzy number (PTFN) is Ã and that can be defined as (l, m, n) shown in Figure 3.1. The membership function $\mu_{\tilde{A}}(x)$is defined as:

$$\mu_{\tilde{A}}(x) = \begin{cases} x - l/_{m - l} & if\ \ l \leq x \leq m \\ n - x/_{n - m} & if\ \ m \leq x \leq n \\ o & otherwise \end{cases} \qquad (3.2.1.2)$$

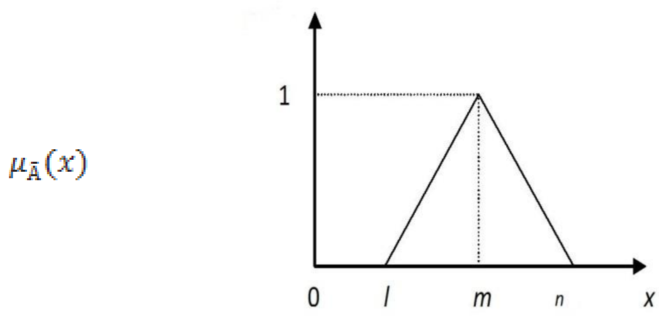


Figure3.1. A triangular fuzzy number Ã

Based on extension principle, the fuzzy sum ⊕ and fuzzy subtraction Θ of any two triangular fuzzy numbers are also triangular fuzzy numbers; but the multiplication ⊗ of any two triangular fuzzy numbers is the only approximate triangular fuzzy number.

Let's have a two PTFNs, such as $\tilde{A}_1$ (l_1; m_1; n_1) and $\tilde{A}_2$ (l_2; m_2; n_2) and a positive real number r=(r, r, r), some algebraic operations can be expressed as follows:

$$\tilde{A}_1 \oplus \tilde{A}_2 = (l_1+l_2,\ m_1+m_2,\ n_1+n_2) \qquad (3.2.1.3)$$

$$\tilde{A}_1 \ominus \tilde{A}_2 = (l_1-l_2,\ m_1-m_2,\ n_1-n_2) \qquad (3.2.1.4)$$

$$\tilde{A}_1 \otimes \tilde{A}_2 = (l_1 l_2,\ m_1 m_2,\ n_1 n_2) \qquad (3.2.1.5)$$

$$r\,\tilde{A}_1 = (\,r l_1,\ r m_1, r n_1) \qquad (3.2.1.6)$$

Also, the crisp value of triangular fuzzy number set $\tilde{A}_i$ can be determined by defuzzification which locates the Best Non-fuzzy Performance (NP) value. This is also known as crisp value thus; the NP values of fuzzy number are calculated by using the center of area method as follows.

$$BNP_i = \frac{[(n-l)+(m-l)]}{3} + l\,, \quad \forall i \qquad (3.2.1.7)$$

3.3 Application of AHP

3.3.1 Structuring of the Hierarchy

A decision problem focused around measuring influences to an overall goal, is arranged and decomposed into its integral parts (i.e. criteria, sub-criteria alternatives, etc.), using a hierarchy

3.3.2 Priority Setting

First of all, one has to find out the importance of various criteria relatively with respect to the objectives. For doing this, one has to prepare a pair-wise comparison matrix as shown in the figure 3.2 using the scale of relative importance. Assuming N criteria, the pairwise comparison of criterion x with criterion y produces a square matrix $\mathbf{A}_{\mathbf{N}\times\mathbf{N}}$

$$
\begin{array}{c|cccccccccc}
c & c_1 & c_2 & c_3 & . & . & c_y & . & . & c_n \\
\hline
c_1 & & & & & & & & & \\
c_2 & & & & & & & & & \\
c_3 & & & & & & & & & \\
. & & & & & & & & & \\
. & & & & & & & & & \\
c_x & & & & & & r_{xy} & & & \\
. & & & & & & & & & \\
. & & & & & & & & & \\
C_n & & & & & & & & &
\end{array}
$$

Figure 3.2 Square matrix

r_{xy}= the relative importance of criterion x with respect to criterion y

$$r_{xy} = 1 \quad \text{when } x = y \qquad (3.3.2.1)$$

$$r_{yx} = {}^{1}/_{r_{xy}} \qquad (3.3.2.2)$$

The decisions are filled using the fundamental scale which is generally used in AHP. The entire criterion compared with it assigned the value 1 always; due to this, the all main diagonal entries in the pairwise comparison matrix will be 1. The values in the pairwise comparison matrix will be represented for the verbal decisions as in table 3.1

Table 3.1 Interpretation of Saatys 1 – 9 scale

Scale	**Interpretation**
1	Equal Importance
3	moderate importance
5	strong importance
7	very strong importance
9	absolute importance
2,4,6,8	negotiation between the earlier values

After this Find out the relative normalized weights (W_x) of all criterion by

i. computing the geometric mean of x_{th} row and
ii. Normalizing the geometric means of all rows in the pairwise comparison matrix. This can be denoted as below

$$GM_x = \left[\prod_{y=i}^{N} r_{xy} \right] \qquad (3.3.2.3)$$

And

$$W_x = {GM_x}/{\sum_{x=i}^{N} GM_x} \qquad (3.3.2.4)$$

In AHP, this geometric mean method is used to calculate the relative normalized weights of all the criteria because of its easiness and simplicity to evaluate the maximum Eigen value and to decrease the inconsistency in decisions.

- Compute matrices A_3 and A_4 such that $A_3 = A_1 \times A_2$ and $A_4 = A_3/A_2$.

  Where $A2 = [W_1, W_2, \ldots, W_N]^T$.
- Determine the maximum eigenvalue (λ_{max}) which is the average of matrix A4.

3.3.3 Consistency Check

Calculate the CI (consistency index) as follows:

$$CI = {(\lambda max - N)}/{(N-1)} \qquad (3.3.3.1)$$

if the value of CI is small, then the deviation from consistency is also small.

Calculate consistency ratio $CR = {CI}/{RI}$ (3.3.3.2)

here the random index (RI) obtained by different orders of the pairwise comparison matrices given in table 3.2

Table 3.2 Random consistency indices

N	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

Usually, a consistency ratio (CR) of 0.1 or less than 0.1 considered as suitable which replicates an unbiased decision of the decision maker.

3.4 Application of Promethee

Decision Maker Preference Function

Step I:

Identification of the selection criteria for the project selection problem and shortlisting of the alternatives on the basis of the criteria satisfying the desires of decision makers. A qualitative or quantitative value or its range will be assigned to each criterion as a threshold value for the acceptance for the considered problem. All alternative with each of the criterion, satisfying the criterion, will be short-listed.

Step II

(1) After shortlisting the all possible alternatives, prepare a decision table which includes the values of all criteria for the all short-listed alternatives.
(2) The relative weights of the importance of the criteria will be calculated using AHP (analytic hierarchy process method) by Saaty (2000).

Step III

After computing the weights of all criteria using AHP method, in the next step, the information about the decision maker’s preference function is to be collected, which they use when comparing the influence of the alternatives in terms of each criterion separately.

The preference function (P_i) translates the difference between the assessments obtained by two alternatives (a1 and a2) in terms of an individual criterion, into a preference degree ranging from 0 to 1. Let $P_{i,a1a2}$ be the preference function related to the criterion $c_{i.}$

$$P_{i,a1a2}=G_i[c_i(a1)-c_i(a2)] \quad (3.4.1.1)$$

$$0\leq P_{i,a1a2}\leq 1 \quad (3.4.1.2)$$

here G_i is a non-decreasing function of the observed deviation (d) between two alternatives a1 and a2 over the criterion c_i. Preference 'usual function' is equal to the simple difference between the values of the criterion ci for alternatives a1 and a2. The 'usual function' is easy to use preference function and is generally used with qualitative criteria. Let the decision maker have specified a preference function P_i and weight w_i for each criterion c_i(i=1, 2,..., N) of the problem. The multiple criteria preference index $\prod_{a1a2}$ is then defined as the weighted average of the preference functions P_i:

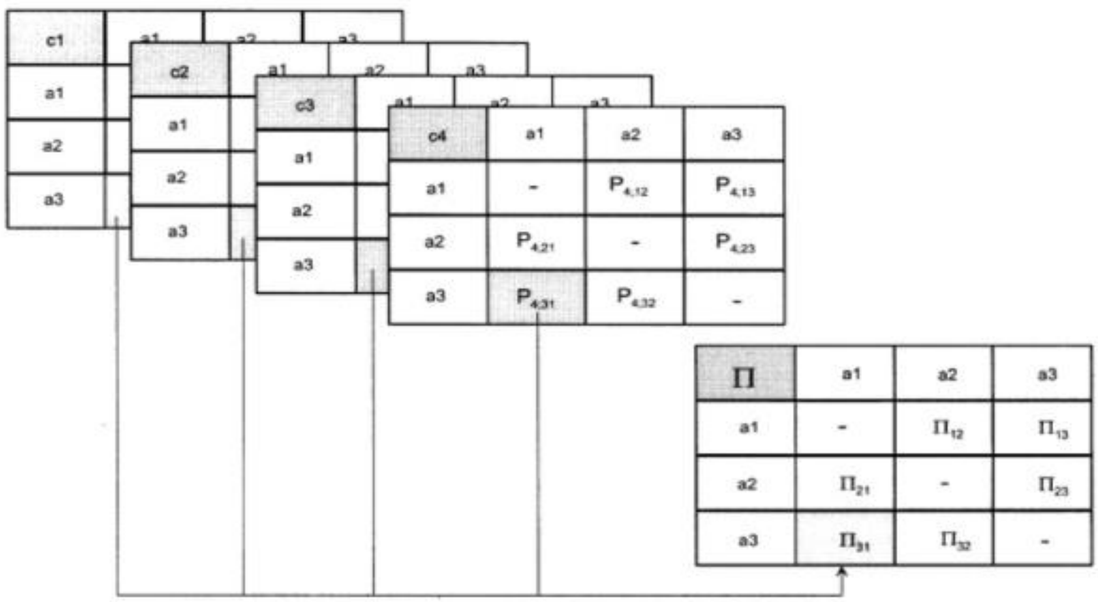
$$\Pi_{a1a2} = \Sigma_{i=1}^{N} w_i P_{i,a1a2} \quad (3.4.1.3)$$

The intensity of preference of alternative a1 over alternative a2 by the decision maker is represented by Π_{a1a2}, when considering all the criteria simultaneously. Its value ranges from 0 to 1. This preference index decides a valued outranking relation on the set of actions. For example, the representative calculation of the preference indices for a problem comprising of four criteria and three alternatives is given in Figure 4.3 (Marinoni, 2005). For PROMETHEE outranking relations, the entering flow, leaving flow and the net flow for an alternative a belonging to a set of alternatives A are calculated as per the following equations:

$$\phi^{+}(a) = \Sigma_{x\epsilon A}\ \Pi_{a1a2} \quad \text{(leaving flow)} \qquad (3.4.1.4)$$

$$\phi^{-}(a) = \Sigma_{x\epsilon A}\ \Pi_{a2a1} \quad \text{(entering flow)} \qquad (3.4.1.5)$$

$$\phi(a) = \phi^{+}(a) - \phi^{-}(a) \quad \text{(net flow)} \qquad (3.4.1.6)$$



$$\Pi_{31} = \Sigma_{i=1}{}^{4} w_i P_{i,31}$$

Figure 3.3 Preference information of a problem consisting of three alternatives and four criteria (Adopted from Marinoni, 2005)

The leaving flow is represented by $\phi^{+}(a)$, the entering flow is represented by $\phi^{-}(a_i)$ and the net flow is represented by $\phi(a_i)$. $\phi^{+}(a)$ measures the outranking character of a (i.e. dominance of alternative a overall other alternatives) and $\phi^{-}(a_i)$ gives the outranked character of a (i.e. degree to which alternative a is dominated by all other alternatives).

The net flow, $\phi(a)$, represents a value function, whereby a higher value reflects a higher attractiveness of alternative a. The net flow values are used to indicate the outranking relationship between the alternatives. For example, for each alternative a, belonging to the set A of alternatives, π_{a1a2} is an overall preference index of a1 over a2, taking into account all the criteria $\phi+(a)$, and $\phi-(a)$. Alternative a1 outranks a2 if ' $\phi(a1) > \phi(a2)$ and a1 is said to be indifferent to a2 if $\phi(a1) = \phi(a2)$.

CHAPTER 4
CASE STUDY

4.1 Company Profile: XYZ Technology Pvt. Ltd. supporting digital agencies from across the North America, Europe & Australia with their Web and Mobile Development needs. The company is based in Gurugram, India provides their clients with a competitive edge on price, time and capabilities. Serving a wide range of global clients, there is a team of 30+ digital specialists, ranging from designers to developers, project managers, quality analysts and SEO consultants having the project which are assigned to different teams. The criteria and the weightage of each criterion are decided by the panel discussion for project selection. This is An MADM (multi attribute decision making) problem. at present the organization using Analytical Hierarchy Process (AHP) for ranking or project selection over the identified decision criteria.

4.2 Problem Formulation:

At present the organization using Analytical Hierarchy Process (AHP) for ranking or project selection over the identified decision criteria. It is well known that AHP requires a lot of input in terms of pairwise comparison of each project over all criteria individually by the decision maker. The other pitfall is that there is no direct consideration to tackle quantitative criteria. The same problem is encountered during project selection. These both problems can be resolved by using ranked family technique like PROMETHEE .therefore Promethee is suggested for selection of the project. But Promethee is also inefficient to consider the interdependencies of selection criteria because there is no described procedure for calculating weights of decision criteria.so recommendations are formulated to integrate into PROMETHEE a number of useful AHP features, especially as regards the design of the decision-making hierarchy and the determination of weights.

Therefore, this research has deployed a simple methodology called PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluations). A ranked value judgment on quantitative criteria and the method is used by combining the Analytic Hierarchy Process (AHP) for determining the relative importance of criteria for information system project selection.

To demonstrate the suggested methodology in decision making, here the problem which is already solved by AHP in the organization is considered. Due to this, the criteria which are considered are some so that comparison should be fair.

The problem consists of five criteria and six alternative projects. The five criteria used to evaluate the six short-listed alternatives. The five criteria are the economic impact (EI), strategic match(SM), risk (RI), competitive impact (CI) and operational impact (OI).

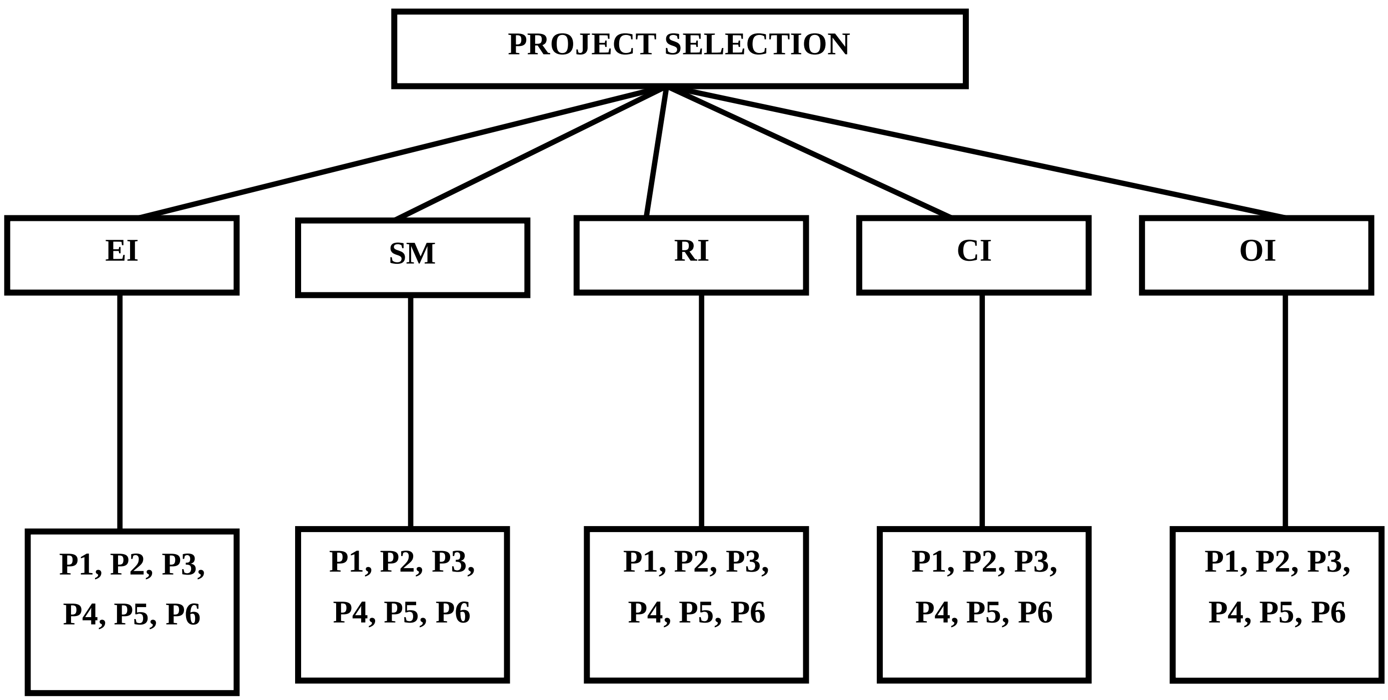


Fig 4.1 hierarchical structure for alternative and criteria

4.3 Solution:

Step I:

For qualitative criterion, the responses of DM's converted on a fuzzy scale according to table 4.1. The value of the criteria for all alternatives first decided as linguistic terms then converted into equivalent fuzzy numbers as shown in table 4.2 and then adapted into the crisp scores for further steps. Table4.3

Table 4.1 Linguistic scales and corresponding fuzzy representation for criteria rating w.r.t. alternatives.

Performance rating	Triangular fuzzy numbers
Very low	(0,0,2)
Low	(0,2,4)
Average	(2,4,6)
High	(4,6,8)
Very high	(6,8,10)

Table 4.2 the responses of DM's for all alternatives

Criteria	Alternatives	Ratings are given by DMs				
		DM1	DM2	DM3	DM4	Aggregated fuzzy rating
EI	P1	H	VH	VH	H	(5,7,9)
SM		A	H	H	VH	(4,6,8)
RI		L	VL	VL	L	(0,1,3)
CI		H	A	VH	H	(4,6,8)
OI		A	A	H	A	(2.5,4.5,6.5)
EI	P2	A	H	H	A	(3,5,7)
SM		H	H	H	A	(3.5,5.5,7.5)
RI		A	L	A	A	(1.5,3.5,5.5)
CI		A	H	A	H	(3,5,7)
OI		H	VH	A	H	(4,6,8)

EI	P3	L	VL	A	L	(0.5,2,4)
SM		A	VH	A	H	(3.5,5.5,7.5)
RI		VH	H	H	A	(4,6,8)
CI		VH	H	H	VH	(5,7,9)
OI		L	A	A	A	(1.5,3.5,5.5)
EI	P4	VH	H	H	H	(4.5,6.5,8.5)
SM		VH	VH	H	A	(4.5,6.5,8.5)
RI		L	L	L	VL	(0,1.5,3.5)
CI		L	A	A	A	(1.5,3.5,5.5)
OI		H	A	H	H	(3.5,5.5,7.5)
EI	P5	L	L	L	VL	(0,1.5,3.5)
SM		L	VL	L	L	(0,1.5,3.5)
RI		H	A	A	H	(3,5,7)
CI		H	VH	A	H	(4,6,8)
OI		L	L	L	H	(1,3,5)
EI	P6	A	A	A	A	(2,4,6)
SM		H	A	VH	H	(4,6,8)
RI		A	A	A	A	(2,4,6)
CI		A	H	H	L	(2.5,4.5,6.5)
OI		A	L	H	A	(2,4,6)

Table 4.3 Result in term of crisp value (using center of area method BNP eq. 3.2.1.7)

	EI	SM	RI	CI	OI
P1	7.00	6.00	1.33	6.00	4.50
P2	5.00	5.50	3.50	5.00	6.00
P3	2.17	5.50	6.00	7.00	3.50
P4	6.50	6.50	1.67	3.50	5.50
P5	1.67	1.67	5.00	6.00	3.00
P6	4.00	6.00	4.00	4.50	4.00

Step II

(1) A decision table comprising the values of all criteria for the eligible alternatives is organized as Table 4.3.

(2) The criteria weights of relative importance are assigned using analytic hierarchy process

(AHP) method as explained in Section 3.3. The decision makers formulate the following matrix which has aggregated value for relative importance of criteria as shown in table 4.4

Table 4.4 aggregated value for relative importance of criteria given by DM's

	ER	SM	RISK	CI	OI
ER	1	3.46	2	2.45	1.22
SM	0.29	1	1.86	0.9	0.93
RISK	0.5	0.54	1	0.97	0.82
CI	0.41	1.11	1.03	1	0.9
OI	0.82	1.07	1.22	1.11	1

The standardized weights of each criteria calculated are presented in table 4.5

Table 4.5 standardized weights of each criteria calculated using AHP

criteria	ER	SM	RISK	CI	OI
weight	0.351	0.163	0.138	0.154	0.194

(3) Consistency Check :

$$\lambda_{max} = 5.147$$

$$N = 5$$

CI (consistency index)

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

$$CI = {(5.147 - 5)}/{(5-1)}$$

$$CI = 0.03657$$

CR(consistency ratio) $CR = {CI}/{RI}$

here the random index (RI) obtained by different orders of the pairwise comparison matrices for N=5 ; RI = 1.12

so $CR = {0.03657}/{1.12}$

$$CR = 0.033$$

The value of CR is lesser than the allowed value (0.1). So, there is decent consistency in the judgments prepared.

Step III:

After considering the weights of the criteria using AHP method, the next step is to have the information on the decision maker preference function, which he/she uses when comparing the contribution of the alternatives in terms of each separate criterion. Let the decision maker use the preference 'usual function' for all criteria. If two alternatives have a difference d $\neq 0$ in criterion c_i, then a preference value ranging between 0 and 1 is assigned to the 'better' alternative whereas the 'worse' alternative receives a value 0. If d=0, then they are indifferent which results in an assignment of 0 to both alternatives.

- Three criteria namely economic impact (EI), strategic match(SM), AND competitive impact (CI) are beneficial and hence higher values are desired.
- Two criteria risk (RI), and operational impacts (OI) are cost criteria hence lower value is desired.

The pairwise comparison of criterion economic impact (EI) gives the matrix given in Table4.6. The project having a comparatively higher value of EI is said to be 'better' than the other.

The Tables 4.6-4.10 show the pairwise comparison with respect to the other project over a criterion.

Table: 4.6 Pair values P resulting from the pairwise comparison of six alternative projects with respect to criterion economic impact

EI 0.351

	P1	P2	P3	P4	P5	P6
P1		1	1	1	1	1
P2	0		1	0	1	1
P3	0	0		0	1	0
P4	0	1	1		1	1
P5	0	0	0	0		0
P6	0	0	1	0	1	

Table: 4.7 Pair values P resulting from the pairwise comparison of six alternative projects with respect to criterion strategic match

SM 0.164

	P1	P2	P3	P4	P5	P6
P1		1	1	0	1	0
P2	0		0	0	1	0
P3	0	0		0	1	0
P4	1	1	1		1	1
P5	0	0	0	0		0
P6	0	1	1	0	1	

Table: 4.8 Pair values P resulting from the pairwise comparison of six alternative projects with respect to criterion risk

RI 0.138

	P1	P2	P3	P4	P5	P6
P1		1	1	1	1	1
P2	0		1	0	1	1
P3	0	0		0	0	0
P4	0	1	1		1	1
P5	0	0	1	0		0
P6	0	0	1	0	1	

Table: 4.9 Pair values P resulting from the pairwise comparison of six alternative project with respect to criterion competitive impact

CI 0.154

	P1	P2	P3	P4	P5	P6
P1		1	0	1	0	1
P2	0		0	1	0	1
P3	1	1		1	1	1
P4	0	0	0		0	0
P5	0	1	0	1		1
P6	0	0	0	1	0	

Table: 4.10 Pair values P resulting from the pairwise comparison of six alternative projects with respect to criterion operational impact

OI	0.193					
	P1	P2	P3	P4	P5	P6
P1		1	0	1	0	0
P2	0		0	0	0	0
P3	1	1		1	0	1
P4	0	1	0		0	0
P5	1	1	1	1		1
P6	1	1	0	1	0	

Table 4.11Resulting preference indices as well as leaving, entering and net flow values

	P1	P2	P3	P4	P5	P6	Φ+	Φ-	Φ	RANK
P1	0	1	0.653	0.836	0.653	0.643	3.785	0.897	2.888	1
P2	0	0	0.489	0.154	0.653	0.643	1.939	2.897	-0.958	5
P3	0.347	0.347	0	0.347	0.669	0.347	2.057	2.779	-0.722	4
P4	0.164	0.846	0.653	0	0.653	0.653	2.969	2.031	0.938	2
P5	0.193	0.347	0.331	0.347	0	0.347	1.565	3.281	-1.716	6
P6	0.193	0.357	0.653	0.347	0.653	0	2.203	2.633	-0.43	3

The leaving flow, entering flow and the net flow values for different alternatives are calculated using Equations 3.4.1.4-3.4.1.6 and the resulting preference indices are given in Table 4.11. Based on the net flow values given in Table 4.11, it is clear that the project P1 designated as A1 is the best choice among the other projects which have been considered first. The ranking of the projects is **P1-P4-P6-P3-P2-P5.**

CHAPTER 5
CONCLUSION

In the previous chapter, we found a complete ranking of alternative projects on the basis of five selection criteria. The ranking attained by AHP in the organization is compared with ranking achieved by hybrid AHP- Promethee as shown in table 5.1 .here we found the ranking are almost same except the intermediate rank. Therefore, the conclusion made by this study is showing that the Hybrid AHP-PROMETHEE can be employed in the organization for project selection problem in future.

Table 5.1 comparison of rank for AHP and Hybrid AHP-PROMETHEE

Alternative	P1	P2	P3	P4	P5	P6
AHP	1	5	3	2	6	4
Hybrid AHP-PROMETHEE	1	5	4	2	6	3

In this thesis, a methodology based on PROMETHEE method is used for decision making .This methodology further helps in selection of an appropriate alternative from a set of available alternatives. The hybrid methodology suggests a method for determination of the criteria weights with the help of analytical hierarchy process and it permits the decision maker to scientifically assign the relative importance of the criteria according to their preferences. The qualitative attributes are represented on a fuzzy conversion scale for assigning the numerical values to the qualitative criteria. The hybrid AHP-PROMETHEE technique is a common method, which can consider a large number of qualitative and quantitative selection criteria at the same time.

Future scope: There can be a further extension of this problem. In the present problem resource feasibility is not considered. So in future, the methodology can be further improved using PROMETHEE-V or other optimization methods which can tackle the resource constraint properly. Besides the AHP techniques offered to obtain the criteria weight, other approaches may also be combined with the methodology and proposed to the decision makers. Especially some newer methodology can be integrated to handle the interdependency among criteria when the number of the criteria is large.

REFERENCES

Abu-Taleb, M.F., Mareschal, B., (1995). Water resources planning in the Middle East: Application of the PROMETHEE V multi criteria method. *European Journal of Operational Research*, 81(3) : 500-511.

Armstrong, J. S., and R. J. Brodie,(1994) .Effects of portfolio planning methods on decision making: Experimental results. *International Journal of Research in Marketing* ,11:73–84.

Babic, Z., Plazibat, N., (1998), Ranking of enterprises based on multicriterial analysis. *Int. J. Production Economics,* 56-57: 29-35.

Bayou, M., Korvin, A.D. and Reinstein, A. (2007).Using the fuzzy-analytic-hierarchical-process to select the optimum mechanism for developing accounting standards. *Review of Accounting and Finance*, 6 (2):109-30.

Ballantine. j., bonner. M. levy. M. and marin a.(1996).The 3-d model of information system success : the search for dependent variable continues. *information resources management journal*, 9 (4) :5-14.

Brans, J.P., Vincke, Ph., & Mareschal, B.(1985). How to select and how to rank projects: The PROMETHEE method. *European Journal of Operational Research*, 24: 228-238.

Carlsson, C., Fullér R., (1995).Multiple criteria decision making: The case for interdependence. *Computers & Operations Research*, 22(3):251-260.

Climaco J, editor. Multi criteria analysis. New York: Springer-Verlag; 1997

Chan, D.C., Yung, K.L. and Lp, A.W.H. (2002).An application of fuzzy sets to process performance. *Integrated Manufacturing Systems*, 13(4): 237-46.

Chen CT & Cheng H-L. (2009) . A comprehensive model for selecting information system project under fuzzy environment. *International Journal of Project Management*, **27**:389–399.

Chen S.-J. and Hwang, C. L., (1992). Fuzzy multiple attribute decision making: Methods and applications. Lecture notes in economics and mathematical systems. 375:289 – 486.

Chang Y.H, Yeh C.H. (2001) .Evaluating airline competitiveness using multi-attribute decision making. *Omega*. 29(5): 405–15

Chen, Y., Larbani, M., and Chang, Y. (2009). Multiobjective data envelopment analysis. *Journal of the Operational Research Society*, 60(11): 1556-1566.

Cheung, S.O., Ng, T., Lam, K.C. and Sin, W.S. (2001).A fuzzy set model for construction dispute evaluation. *Construction Innovation: Information, Process Management*, 1(2):117-27

Daengdej, J., Lukose, D., and Murison, R. (1999). Using statistical models and case-based reasoning in claims prediction: experience from a real-world problem. *Knowledge-Based Systems*, 12(5-6): 239-245.

Doherty N. F., Marples C. G. and Suhaimi A.(1999).The relative success of alternative approaches to strategic information system planning: an empirical analysis .*The Journal of Strategic Information Systems*, **8**: 263–283..

Gabriel, S.A., Kumar, S., Ordonez, J., Nasserian, A.(2006) .A multi objective optimization model for project selection with probabilistic considerations. *Socio-Economic Planning Sciences*, 40(4) : 297-313.

Ghorabaee, M.K. (2016), "Developing an MCDM method for robot selection with interval type-2 fuzzy sets", *Robotics and Computer-Integrated Manufacturing*. 37: 221-232.

Jain, B.A., Nag, B.N., (1996).A Decision Support Model for Investment Decisions in new Ventures. *European Journal of Operational Research*", 90:473-486.

Kapoor, V. and Tak, S.S. (2005).Fuzzy application to the analytic hierarchy process for robot Selection. *Fuzzy Optimization and Decision Making*, 4 (3) : 209-234.

Karasakal, E., Özerol, G. (2006). Incorporating Prospect Theory into an Outranking Method for MCDM under Imprecise information, Technical Report 06-06, Department of Industrial Engineering, METU, Ankara, Turkey

Keeney, R.L. & Raiffa, H. (1976). Decisions with multiple objectives: Preferences and values tradeoffs, New York: Wiley.

Khorramshahgol, R., Azani, H., and Gousty, Y. (1988).An integrated approach to project evaluation and selection. *IEEE Transactions on Engineering Management*, EM-35(4): 265-270

Korvin, A.D., Strawser, J. and Siegel, P.H. (1995). An application of control system to cost variance analysis. *Managerial Finance*, 21 (3): 17-35.

Kwak, N.K., Lee, C.(1998).A multi criteria decision-making approach to university resource allocations and information infrastructure planning. *European Journal of Operational Research*, 110:234-242.

Lee, J.W., Kim, S.H., (2001). An integrated approach for interdependent information system project selection. *International Journal of Project Management*, 19:111-118.

Macharis, C., Springael, J., De Brucker, K., Verbeke, A. (2004). PROMETHEE and AHP: The design of operational synergies in multi criteria analysis. Strengthening PROMETHEE with ideas of AHP. *European Journal of Operational Research*, 153:307–317.

Mavrakis, D., and Konidari, P (2007). A multi-criteria evaluation method for climate change mitigation policy instruments. *Energy Policy*, 35(12): 6235-6257

Mavrotas, G., Diakoulaki, D., Caloghirou, Y., (2006) Project prioritization under policy restrictions. A combination of MCDA with 0–1 programming. *European Journal of Operational Research*, 171(1):296-308

Meade L.M., Presley, A. (2002). R & D project selection Using the Analytic Network Process. *IEEE Transactions on Engineering Manageent* .49(1).

MEHREZ A, HOWARD GS, LUGASSI Y & SHOVAL P. (1993). Information System Planning and Selection: A Multi attributes Theoretic Approach. *The Computer Journal*, **36**: 525–541.

Milis K & Mercken R. (2004).The Use of the Balanced scorecard for the evaluation of Information and Communication Technology projects. *International Journal of Project Management*, 22: 87–97.

Moselhi Osama and Bikash Deb (2006).Project Selection Considering Risk. *Construction Management and Economics*, 11:1:45-52.

Opricovic S. and Gwo-Hshiung Tzeng(2004).Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS. *European Journal of Operational Research* 156:445–455

Ostermark, R. (1997). Temporal interdependence in fuzzy MCDM problems. *Fuzzy Sets and Systems* 88: 69 -79

Pohekar S.D and Ramachandran, M.(2004). Application of multi-criteria decision making to sustainable energy planning: A review. *Renewable and Sustainable Energy Reviews*,8:365–381

Qin, X., Huang, G., Chakma, A., Nie, X., and Lin, Q.(2008) . A MCDM-based expert system for climate-change impact assessment and adaptation planning – A case study for the Georgia Basin, Canada. *Expert Systems with Applications*.34(3): 2164-2179.

Rao, R. V. & Patel, B.K. (2010).Decision making in the manufacturing environment using an improved PROMETHEE method. *International Journal of Production Research*, 48:16, 4665-4682.

Rao, R.V., Patel, B.K. and Parnichkun, M. (2011).Industrial robot selection using a novel decision making method considering objective and subjective preferences. *Robotics and Autonomous Systems*,59(6):367-375.

Saaty TL. (1980). The analytic hierarchy process. New York: McGraw-Hill

Saaty, T.L., Takizawa, M.(1986).Dependence and independence: from linear hierarchies to non-linear networks. *European Journal Operational Research*. 26 :229-237.

Saaty,T.L.(1999) “Fundamentals of the Analytic Network Process,” Proceedings of the Fifth International symposium of the Analytic Hierarchy Process, Kobe, Japan, August 12-14,

Santhanam, R., Kyparisis, J. (1995). A multiple criteria decision model for information system project selection. *Computers Ops. Res*.22(8):807- 818

Sen D. K., Datta S andMahapatra S.S. (2016).Extension of PROMETHEE for robot selection decision making", *Benchmarking: An International Journal*, 23 (4):983 - 1014

Shyur, H.J., Shih H.S., (2005). A Hybrid MCDM Model for Strategic Vendor Selection. *Mathematical and Computer Modeling* 44:749-761

Solnes J.(2003).Environmental quality indexing of large industrial development alternatives using AHP. *Environmental Impact Assessment Review*, 23(3):283–303.

Stewart R. and Mohamed S.(2002)IT/IS projects selection using multi-criteria utility theory”, *Logistics Information Management*, 15(4):254 – 270.

Tanaka, H., Okuda, T. and Asai, K. (1976).A formulation of fuzzy decision problems and its application to an investment problem. *Kybernetes*, 5 (1):25-30.

Tavana, M.(2003).A multicriteria group-decision -making model for evaluating and prioritizing advanced technology projects at NASA. *Interfaces*, 33(3) :40–56 2003,

Thomaidis, N., Nikitakos, N. and Dounias, G. (2006).The evaluation of information technology projects: a fuzzy multicriteria decision-making approach. *International Journal of Information Technology & Decision Making*, 5 (1) :89-122.

Thanassoulis, E., Kortelainen, M., and Allen, R. (2012). Improving envelopment in data envelopment analysis under variable returns to scale. *European Journal of Operational Research*, 218(1): 175-185.

Tsourveloudis, N.C. and Phillis, Y.A. (1998). Manufacturing flexibility measurement: a fuzzy logic framework", *IEEE Transactions on Robotics and Automation*. 14 (4):513-24.

Ulutas, B.H. (2005). Determination of the appropriate energy policy for Turkey. *Energy*. 30:1146–1161

Wang, Y., Greatbanks, R., and Yang, B. (2005). Interval efficiency assessment using data envelopment analysis. *Fuzzy Sets and Systems*, 153(3): 347-370.

Wang, J.J., Yang, D.L. (2006). Using a hybrid multi-criteria decision aid method for information systems outsourcing, *Computers & Operations Research*, 34:3691 – 3700

Zadeh, L.A. (1965), Fuzzy sets. *Information and control*. 8 (3):338-353.

Zopounidis C., (1999) Multi criteria decision aid in financial management. *European Journal of Operational Research*. 119: 404–415.