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Mathematical Modeling of Interrelationship Analysis to Determine Multi-Criteria Decision Making Casual Relations

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Abstract: *The Multi Criteria Decision Making (MCDM) delivers strong decision making in areas where selection of best alternative is highly complex. This paper reviews and explain the main condensations of MCDM models and practices in detail. The purpose is explained and identify various application and the approaches and to suggests different MCDM models for different decision makling issues and how to select the best alternatives. This paper also examines the DEMATEL model and problems in DEMATEL for decision making and how DEMATEL have been improved to overcome the problems. The MCDM methods have helped to choose the best alternatives where that they are many criteria are present, the best can be selected and analyzed the different scope for the criteria, weights for the criteria and the choose the ideal ones using any multi criteria decision making methods.*

Keywords: Multi Criteri Decision Making, DEMATEL, Alternatives, Methods, Selecting best criteria, Casual relations.

1.0 INTRODUCTION

In our day today life, so many decisions are being made from various criteria, so decisions can be made by providing weights to different criteria and all the weights are obtained from expert groups [12]. It is essential to determine the structure of the problem and explicitly evaluate multi criteria.

Multi-Criteria Decision Making (MCDM) method has been used in credibility over the last of recent decades. MCDM refers to making decisions in the presence multiple but usually conflicting criteria [8]. MCDM approach is used for the problems that are more complicated and usually of large scale. For instance, many organizations in US and Europe are conducting self-assessment that using many criteria and sub-criteria set in Quality Management System (QSM) business excellence model [27]. In large organizations the purchasing departments often need to evaluate their suppliers by using the range of criteria in a different area, such as after sale service, quality management and financial stability. Although MCDM problems are extensive all the time, MCDM as a disciple only has a relatively short history of about 30 years [10]. MCDM is an advantageous tool in many economies, material selection, manufacturing, construction and etc. problems, particularly plays a significant role in fields of investment decision, project evaluation, staff appraisal and so on [11]. There have been many techniques offered to solve multiple attribute decision making problems. Multi-Attribute Decision Making (MCDM) is a study of classifying and selecting alternatives based on the values and preference of the decision maker [19] In MCDM making a decision implies that there are alternative choices to be considered and in such case we won't only to identify as many of these alternative as possible, but to take on that best fits with the ultimate goal, objective, desires and value [19]. Figure 1 demonstrates the basic framework of MCDM for solving multiple criteria in relation to alternatives to choose best for the goal.

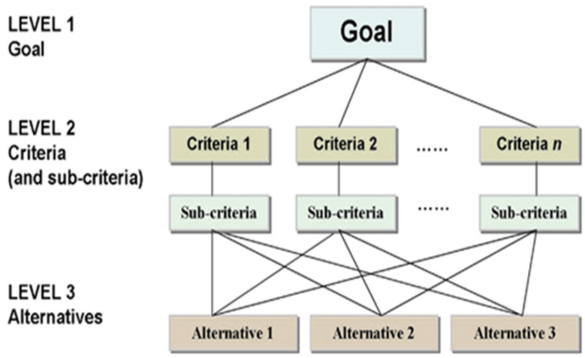

Figure 1: The Hierarchy of MCDM frame work

The development and progress of the MCDM disciple is a closely connected to the progression of computer technology. Moreover, the fast development of computer technology in recent years has made it possible to demeanour systematic analysis of complex MCDM process in problems [2] On the other hand, the extensive use of computers and information technology has generated a huge amount of information that makes MCDM increasingly important and useful in supporting business decision making [2].

Alternatives often represents different choices of action that is available to the decision maker. For instance, the general goal depends on two or 3 criteria or sub criteria that is under criteria [27]. Since different criteria represent different dimensions of alternatives, they may conflict with each other. For example, costs may conflict with profit. Essentially, MCDM problems can be interpreted by solving with choosing best alternatives from a set of available alternatives, choosing a small set of good alternatives into different preference of sets or an extreme interpretation could be find all efficient or non-dominated alternatives.

1.2 Objectives of This Paper

The objective of this paper is to identify and explain each of MCDM's tools and models and how we are able to apply them for conflicting criteria and problems in order to make the best decision to solve the problem. This paper attempts to give an overview some of the most important features of solving MCDM problems, to categorize MCDM models into appropriate solving problems and describe briefly the various algorithms that have been developed to solve MCDM models in each class. This paper hopes to give an introduction to readers, researches and students complex and diverse classes of MCDM models and how to utilize each for decision making.

Journal of Advanced Research Design
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2.0 REVIEW AND ANALYSIS OF MCDM METHODS

MCDM methods have been applied to different applications and find the best explanation to select the best alternative.

They are many methods obtainable for solving MCDM problems as studied by Hwang and Yoon [15], nonetheless some of the methods were criticized as to certain degree unjustified on theoretical and empirical grounds. According to Zimmermann [13] MCDM is separated into Multi-Attribute Decision Making (MADM) and Multi-Objective Decision Making (MODM), where MODM studies decision problems in which the decision space is continuous. A typical example is mathematical

Programming problems with multiple objective functions, the first reference is known as "Vector-Maximum" problem [16]. Instead, mostly concentrate on problems that the set of decision alternatives been predetermined. Even though MCDM methods maybe extensively diverse, many of them have certain features in common [5-15]. These are notions of alternatives and attributes, also called decision criteria. The figure 2 shows the hierarchical view of MCDM methods and its types.

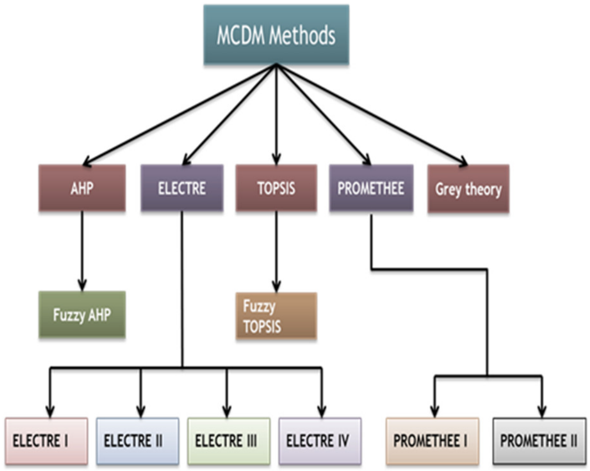

Figure 2. Hierarchical MCDM methods

2.1. Analytic Hierarchical Process (AHP):

The basic knowledge of AHP is to capture the expert's ideas of the phenomena under study. Using the concepts of fuzzy set theory and the hierarchical systematic approach is followed for alternatives selection and justification problem [14]. AHP is based on decomposing a complex MCDM problem into a system of hierarchies (more on these hierarchies can be found in [20].

Decision makers often find that it is more confident to give interval judgments than fixed value judgments. When a user preference is not defined explicitly due to fuzzy nature this method can be applied. AHP consists of the opinions of experts and multi-criteria evaluation it is not capable of reflecting human's imprecise thoughts [18] The classical AHP considers the definite judgments of decision makers, thus the fuzzy set theory makes the comparison process more flexible and capable to explain experts' preferences. The Analytic Hierarchy Process (AHP) decomposes a difficult MCDM problem into a systematic hierarchy procedure [17].

The final step in the AHP deals with the structure of an M×N matrix (where M is the number of alternatives and N is the number of criteria). This matrix is made by using the comparative

Journal of Advanced Research Design
ISSN (online): 2462-1943 I Vol. 20, No. 1. Pages 18-33, 2016

importance of alternatives in terms of each criterion [21]. The vector (ai1, ai2, ai3…,aiN) for each i is the principle eigenvector of an N×N reciprocal matrix which is determined by alternatives on i-the criterion.

Thomas Satty [20] firstly developed the Analytic Hierarchical process to allow decision making in situations characterized to multiple attributes and alternatives. AHP is one of the multi criteria decision making techniques. AHP has been applied effectively in many areas of decision making. In short, it is a method to derive ratio scales from paired comparison.

Satty examined the method used in AHP to process the aij values after they been determined. The entry age, in the M×N matrix, represents the relative value of the alternative AI when it is considered in terms of criterion Cj.

According to Satty the best alternative in AHP (in Maximization case) is shown by the following relationship:

AAHP*= maxi $\sum_{j=1}^{N} qij\ wj$, for i= 1, 2, 3 ..., M.

The AHP uses relative values instead of actual ones. Hence, it can be used in single or multi-dimensional decision making problems. The uses a series of pairwise comparisons to determine the relative performance of each alternative in terms of each one of the decision criteria . AHP uses relative data instead of absolute data.

Table 1. AHP Criteria Relation

	Criteria			
Alt.	C1 0.20	C2 0.15	C3 0.40	C4 0.25
A1	25/65	20/55	16/65	30/65
A2	10/65	30/55	20/65	30/65
A3	30/65	5/55	30/65	5/65

That is the column in decision matrix that have been normalized to add up to 1. When formula is applied on the data, the following outcome are derived:

A1 (AHP score) = (25/65) ×0.20 + (20/55) ×0.15 + (15/65) ×0.40 + (30/65) ×0.25 = 0.34.

And respectively for:

A2 (AHP score) = 0.35.

A3 (AHP score) = 0.31.

Thus, the best alternative for maximization case is A2 since it has highest AHP score. Then, the following rank is derived: A2>A1>A2

Journal of Advanced Research Design
ISSN (online): 2462-1943 I Vol. 20, No. 1. Pages 18-33, 2016

2.1.1 Fuzzy AHP:

Fuzzy AHP uses fuzzy set theory to express the uncertain comparison judgments as a fuzzy numbers. The main steps of fuzzy AHP are as follows:

(1) Structuring decision hierarchy. Similar to conventional AHP, the first step is to break down the complex decision making problem into a hierarchical structure.

(2) Developing pairwise fuzzy comparison matrices. Consider a prioritization problem at a level with n elements, where pair-wise comparison judgments are represented by fuzzy triangular numbers aij (iij , mij, uij). As in the conventional AHP, each set of comparisons for a level requires (n1)/2 judgments, which are further used to construct a positive fuzzy reciprocal comparison matrix A ={aij}, such that:

$$A\text{-}\{ain\}\text{-}\begin{pmatrix} a12 & \mathrm{a12} & \cdots & a1n \\ \vdots & & \ddots & \vdots \\ a21 & a22 & \cdots & a2n \\ . & & . & . \\ . & & . & . \\ . & & . & . \\ an1 & an2 & . & amn \end{pmatrix}$$

Source: Fuzzy AHP prioritizing

(3) Consistency check and deriving priorities. This step checks for consistency and extracts the priorities from the pairwise comparison matrices. In existing fuzzy AHP methods, only a few past studies have addressed the issue of checking for inconsistencies in pairwise comparison matrices. According to previous research, a fuzzy comparison matrix A ={aij} is consistent if

$a_{ki} = a_{ij}$,where I,k,j=1,2….n.

Once the pairwise comparison matrix, ~A, passes the consistency check, fuzzy priorities ~wi can be calculated with conventional fuzzy AHP methods. Then, the priority vector (w_1, w2, w3,….,w_n) can be obtained from the comparison matrix by applying a prioritization method.

(4) Aggregation of priorities and ranking the alternatives. The final step aggregates local priorities obtained at different levels of the decision hierarchy into composite global priorities for the alternatives based on the weighted sum method. f there are i alternatives and j criteria, then the final global priority of alternative i is given as:

ISSN (online): 2462-1943 I Vol. 20, No. 1. Pages 18-33, 2016

Table 2. Fuzzy Judements Scores in AHP

Fuzzy Judgments scores in Fuzzy AHP	
Fuzzy Judgments	Fuzzy Score
About equal	(1/2, 1,2)
About x times more important	(x-1,x,x+1)
About x times less important	(1/(x+1),1/x,1/(x-1)
Between y and z times more important	(y/(y+z)/2,z)
Between y and z times less important	(1/z,2/(y+z),1/y)

Fuzzy analytic hierarchy process (AHP) proves to be a very useful methodology for multiple criteria decision-making in fuzzy environments, which has found substantial applications in recent years [22].

2.2 Electre:

ELECTRE, along with its many iterations, is an outranking method based on concordance analysis. Its major advantage is that it takes into account uncertainty and vagueness. One disadvantage is that its process and outcomes can be hard to explain in layman's terms. Further, due to the way preferences are incorporated, the lowest performances under certain criteria are not displayed. The outranking method causes the strengths and weaknesses of the alternatives to not be directly identified, nor results and impacts to be verified [29]. ELECTRE has been used in energy, economics, environmental, water management, and transportation problems. Like other methods, it also takes uncertainty and vagueness into account, which many of the mentioned applications appear to need.

2.3 Topsis:

TOPSIS (The Technique for order Preference by Similarity to Ideal Solution) was developed by as an alternative approach to the ELECTRE method. The basic concept of the TOPSIS method is that the selected alternative should have the shortest distance from idea solution and the farthest distance from negative-ideal solution in a geometrical sense [8-4] . TOPSIS undertakes that each attribute has a tendency of monotonically increasing or decreasing utility. Therefore, it is easy to find the ideal and negative ideal solution. The Euclidean distance approach is used to appraise the relative familiarity of alternative to ideal solution [23]. Hence, the preference order of alternative is yielded through comparing these relative distances.

The TOPSIS approach evaluates the following decision matrix that refers to M as alternative which are evaluated in terms of N as criteria:

Journal of Advanced Research Design
ISSN (online): 2462-1943 I Vol. 20, No. 1. Pages 18-33, 2016

$$D = \begin{bmatrix} X11\ X12\ X13\ \dots & ,X1n \\ X21\ X22\ X23\ \dots & X2n \\ . & . \\ . & . \\ . & . \\ XM1\ XM2\ XM3\ \dots & XMn \end{bmatrix}$$

in the TOPSIS method the number of steps remains the same regardless of the number of attributes [24]. A disadvantage is that its use of Euclidean Distance does not consider the correlation of attributes. It is difficult to weight attributes and keep consistency of judgement, particularly with additional attributes. TOPSIS can be expressed in following steps:

1) Calculating normalized matrix. The normalized value nij is calculated as

$$\text{nij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}^2} \text{ for i=1,…,m and j=1,…,n.}$$

2) Calculate the weighted normalized decision matrix. The weighted normalized value Vij is calculated as Vij=Wi Nij for i=1,…,m and j=1,…,n where wi is the weight of the ith attribute or criterion, and View the MathML source. These weights can be introduced by a decision maker

3) To Determine positive ideal and negative ideal solution:

A+={(v+1,v+2,…,v+n)}={(maxvij|i∈O),(minvij|i∈I)}

A−={(v−1,v−2,…,v−n)}={(minvij|i∈O),(maxvij|

Where in this equation O is associated with benefit criteria, and I is associated with cost criteria.

4) Calculate the separation measures by using n=dimensional Euclidean distance. The separation of every alternative from the ideal solution is calculated given as:

d_j^+= [∑ni=1(vij−v_1^+)]1/2

And similar and comparable from negative ideal solution is followed as:

d_j^-= [∑ni=1(vij−v_1^-)]1/2

5) Ranking the preference order to decideThe basic principle of the TOPSIS method is that the chosen alternative should have the “shortest distance” from the ideal solution and the “farthest distance” from the negative-ideal solution

2.4 Promethee:

PROMETHEE is similar to ELECTRE in that it also has several repetitions and it also an outranking method. The PROMETHEE family of outranking methods, including PROMETHEE 1 for partial ranking of the alternatives and the PROMETHEE II for complete

Journal of Advanced Research Design
ISSN (online): 2462-1943 I Vol. 20, No. 1. Pages 18-33, 2016

ranking of alternatives, were developed and presented for the first time in 1982. Few ears later , several versions of the PROMETHEE method such as PROMETHEE III for ranking based on interval and PROMETHEE IV for entire or partial ranking of alternatives when the set of feasible answer is continuous , the PROMETHEE V for the problems with division and subdivision. Constrains, the PROMETHEE VI for the human brain representation [25].

PROMETHEE method has benefits and limitation such as it is easy to implement which does not require assumption the criteria re propionate. But the limitation of PROMETHEE method it does not provide clear method by which to assign weights and it requires the assignment of values but does not provide clear process by which assign the value. The area PROMETHEE has been used are mostly in environmental management hydrology and water management, financial management, logistic and transportation management [2-9]

2.5 Grey Theory:

The Grey Theory is the method that is used to study uncertainty and being superior in the mathematical analysis of systems with uncertain and undefined information. Grey Theory method is used to solve uncertain issues with separate data and incomplete information [3] The Grey Theory was first introduced and applied by 1982 in order to manage with situations categorized by partially known and partially unknown information.

The Grey theory method includes several major parts includes: Grey Prediction , Grey Rational Analysis , Grey Decision and Grey Control [6].

3.0 LITRATURE REVIEW OF DEMATEL USED IN PREVIOUS RESEARCH

Some abilities DEMATEL were identified when reviewing previous studies using this method to solve a problem. Detcharat Sumrit, and Pongpun Anuntavoranich [2] was used DEMATEL to analyze the importance of criteria and the causal relations among the criteria in the field of technology innovation capabilities of enterprises evaluation factors. Knowing the importance of and the relationship between variables is important because it can give a clear picture of the areas that need to be emphasized. Shih Kuang-Husn, Wan-Rung Lin, Yi-Hsien Wang, and Tzu-En Hung [1] have used a combination DEMATEL and Analytic Network Process (ANP) to solve the complex relations between criteria, in order to establish an ideal model system implementation. The study is concerned with the objective to improve the ability of the operating system and managerial decision making through the creation of information systems for enterprises. Jiunn-I Shieh a, Hsin-Hung Wub, Kuan-Kai Huang [1] also used DEMATEL in the study on the management of the hospital organization, with the aim of attracting loyal customers and give treatment, with a satisfaction that is expected by every patient. After getting a list of the major criteria, they used DEMATEL to identify which criteria are most important and the relationship between each of the criteria. Hsiu Yuan Hu, Shao-I Chiu, Tieh-Min Yen, and Ching-Cheng Chan used to DEMATEL identify the impact of the casual relationship between the variable of evaluation items, and to adjust the level between each item f importance, and solve complex and difficult practical problem of causation issue. They intend to assist the business organization to process supplier quality performance rating and find the core improvement direction to create the value of all supply chain members.

As the conclusion, DEMATEL is specially used to identify the variables that are most important and the relationship of each variable by following a step and a specific formula the results from the responses received by the expert or respondent.

Journal of Advanced Research Design
ISSN (online): 2462-1943 I Vol. 20, No. 1. Pages 18-33, 2016

4.0 TECHNICAL NOTES ON USED OF DEMATEL

DEMATEL have some step that needs to be done to get the answers to the problems. The first step is, calculate the average matrix. A study shall have H respondent or expert who will answer questions, and several factors, n. For example, the question asked is "How much inclination factor i affecting factor j?. These pairwise comparisons between all the list of factors made two by two, and will be present through the formula xij.. Normally, it signifies that the integers 0-4 are ascribed to these comparisons [2] where zero means' no influence 'of the I factor in j factor, while 1 indicate as 'very low influence ', 2 is' medium / low influence ', 3 represents' high influence' and the last 4 is' very high influence '. However, a number between 0-10 or 0-100 can also be used depending on the questions and what to investigate. Of course, the value selected by the respondent to answer each factor affects the other factors in a matrix with nonnegative nxn answers, Xk = [xijk] in a way that,$1 \leq k \leq H$. Therefore, X1, X2, … , X H is the answer matrix for each of the respondent, and each X k element is an integer which is represented by xkij . The diagonal elements of each answer matrix X k are all set to zero. Then, by calculating the formula below, we can calculate mean A, n×n matrix [1-2] for all the experts' opinions by obtaining the mean of H scores as follows:

$$a_{ij} = \frac{1}{H} \sum_{k=1}^{H} x_{ij}^{k}$$

The average matrix A=[aij] known as initial direct relation matrix [1]. Matrix A indicated that the initial direct effects that one factor has on the other or the way it is affected by other factors. Furthermore, we can depict the causal relation between each pair of factors by drawing an influence map within a system. It should be mentioned that this matrix is the result of interviewing the selected respondents.

The normalized initial direct-relation matrix should be calculated. Matrix A would be turn to normalized initial direct-relation matrix which is called matrix D as follows.

$$m = \min \left[\frac{1}{\max \sum_{j=1}^{n} |a_{ij}|}, \frac{1}{\max \sum_{i=1}^{n} |a_{ij}|}\right] :$$

Then: $D = m \times A$

$$\max \sum_{j=1}^{n} |a_{ij}|$$

After getting the value of normalized initial direct-relation matrix, then we should calculate the indirect influence matrix by following this formula;

$$ID = \sum_{i=2}^{\infty} D^{i} = D^{2}(I - D)^{-1}$$

We will obtain matrix and graph from it, in fact, represent the relations of strategic decision made by experts with each other. It should be noted that in some cases, elements do not have a direct effect on one another and inevitably we need to calculate indirect effects so that finally we may show the effect of each element on the other elements.

When completed follow one by one step to get the effect of factors that are involved, then the sequence of occurrence of elements is met. Then, we could determine the possible hierarchy or

Journal of Advanced Research Design
ISSN (online): 2462-1943 | Vol. 20, No. 1. Pages 18-33, 2016

structure of the elements. The influence of presumed elements of problem on the other elements or their being influenced is definitely indicative the possible structure of the element hierarchy in improving or solving the problem.

5.0 APPLICATION PROS AND CONS

As discussed in the introduction, DEMATEL has been used successfully used in various fields. Originally, DEMATEL was designed to solve the problems of the disintegrated and conflicting phenomena of word communities and exploration for merging solutions. For example, DEMATEL has been used in the complicated world problems, such as race, energy, environmental protection, and business management. However, today, it is widely used in analyzing world problematic decision making to industrial planning issue. The advantage of DEMATEL is, it may disclose the structure or framework of the complex causal relationships among the factors involved in the system, and DEMATEL can show the level of influence each of the factors involved. As a result, it gave way to the manager how to improve the performance of some issues. DEMATEL also help researchers and managers in understanding more carefully about the specific problem, the cluster of intertwined difficulties and contribute to the diagnosis of practicable solutions by a hierarchical structure [27]. DEMATEL uses causal diagrams to perceive the interdependence among the elements in the system. Causal diagram uses Digraph and not directionless graphs to reveal the basic concept of contextual relationships and the strengths of influence among the elements. Digraphs are more practical than directionless graphs because digraphs can indicate the directed relationships of sub-systems [27-28]. Furthermore the digraphs portray a fundamental concept of contextual relations between the principles of the system, in which the figure represents the potency of influence and separate the involved factors into cause group and effect group. In addition, DEMATEL is able to defind which critical factors that influence the phenomenon in the complex structure of a system because it is using an analytic technique of relationship structure. By applying DEMATEL, we could quantitatively extract interrelationship among multiple factors contained in the problematic issue. In this case, not only the direct but also the indirect influences among multiple factors are taken into account. However, there are a few drawbacks to consider before using this method to resolve the problems. Among the disadvantages of DEMATEL, is when too many factors involved as it will affect the effort made by the analyst which need geometrically. For this reason, some screening process to reduce the number of barriers will be done, before starting DEMATEL process. Also, problems will occur if the information obtained is incomplete and have epistemic uncertainty. However, to address this problem, usually the researchers would use fuzzy numbers in practice of DEMATEL. Another disadvantage is DEMATEL unable to show the absolute degree of relations between the criteria or factors, it means that it is difficult for the analyst to see the direct influence of each criteria.

6.0 LATEST IMPROVEMENT

Due to limitations and shortcomings in DEMATEL model such as not demonstrating absolute answers in decision making, many current researchers continued to improve DEMATEL by suggesting approaches to address the complexity issues in primary DEMATEL method that has been applied in decision making applications [26]. Therefore, many researchers have proposed new hybrid methods with DEMATEL to cover the deficiency by new formulation such as Expanded DEMATEL, FUZZY DEMATEL and DEMATEL-ANP methods added up

Journal of Advanced Research Design
ISSN (online): 2462-1943 I Vol. 20, No. 1. Pages 18-33, 2016

for improvement of primary DEMATEL[26]. For instance, the Expanded DEMATEL was proposed to determine cause and influence factors between separate criteria that have direct impact on each other (Shahryar, 2014). Subsequently, all the criteria can be divided in relation to the cause and influence group by using new method of Expanded DEMATEL which as follows :

Criteria a:

$$(R+C)OP = ROP+COP,$$

$$(R-C)OP = ROP - COP.$$

Criteria b:

$$(R+C)GC = R\ GC + RGC,$$

$$(R-C)GC = R\ GC - RGC.$$

In These relations, rationally one of the criteria and its related factors are more influential and powerful than other one, which means the stronger criteria should be consider as the cause and influential one.

Table 3: Fuzzy Dematel criteria Interacion

	Cause group Ra			Effect group Rb	
	(R+C)OP	(R-C)OP		(R+C)GC	(R-C)GC
OP1	6.301	1.125	GL1	5.627	−1.071
OP2	5.761	0.395	GL2	6.59	−0.686
OP3	5.052	0.88	GL3	4.479	−0.347
OP4	5.362	1.108	GL4	2.082	−0.868

In addition, Fuzzy DEMATEL was employed to assess the direction and level of interaction between criteria Using the DEMTAEL in a Fuzzy context will provide a insight analysis the casual relationship of fuzzy variables and determine the level of interaction influence between variables for researchers. The fuzzy DEMATEL method had been applied successfully in the many decision making problems. Many researchers have used this method in combination with other multicriteria decision analysis such as MCDM method. The fuzzy DEMATEL method is proposed in following steps:

Step 1, Normalization:

$$xl_j^i = \frac{(I_{ij}^k - \min I_{ij}^k)}{\Delta_{min}^{max}}$$

$$Xm_{ij}^k = \frac{(m_{ij}^k - \min I_{ij}^k)}{\Delta_{min}^{max}}$$

Journal of Advanced Research Design
ISSN (online): 2462-1943 I Vol. 20, No. 1. Pages 18-33, 2016

$$Xr_{ij}^{k} = \frac{(r_{ij}^{k} - \min I_{ij}^{k})}{\Delta_{min}^{max}}$$

Where Δ_{Min}^{Max} = max r kij - min I kij

Step 2, Calculate Is and Rs normalized values:

$$Xls_{Ij}^{K} = \frac{xm_{ij}^{k}}{(1 + xm_{ij}^{k} - xi_{ij}^{k})}$$

$$Xrs_{ij}^{K} = \frac{xr_{ij}^{k}}{(1 + xr_{ij}^{k} - xm_{ij}^{k})}$$

Step 3, calculate the complete normalized value:

$$\text{Xkij} = \frac{[xls_{ij}^{k}\left(1 - xls_{ij}^{k}\right) + xrs_{ij}^{k}\ xrs_{ij}^{k}]}{[1 - xls_{ij}^{k} + xrs_{ij}^{k}]}$$

Step 4, calculate the overall normalized value:

Zkij = min Ikij + xkij Δ_{min}^{max}

Step 5, Integrate the value:

$$\text{Zki} = \frac{1}{p}\ (z_{ij}^{1} + z_{ij}^{2} + \ldots\ldots.\ z_{ij}^{p})$$

Source: A Fuzzy DEMATEL framework for modeling cause and effect relationships of strategy map.

Another improvement was done on DEMATEL was integrating with AHP model. The improvement based on cause-oriented which the major improvement of integrating AHP and DEMATEL method is that decision maker can continuously analyses criteria performance affecting each other for both short-term and long term view point to identify the main criteria to improve the performance (Hung, 2009). Base on this AHP can help DEMATEL to rank the criteria in preferred order to select the best criteria for performance improvement [21]. The diagram of AHP and DEMATEL hybrid follows below:

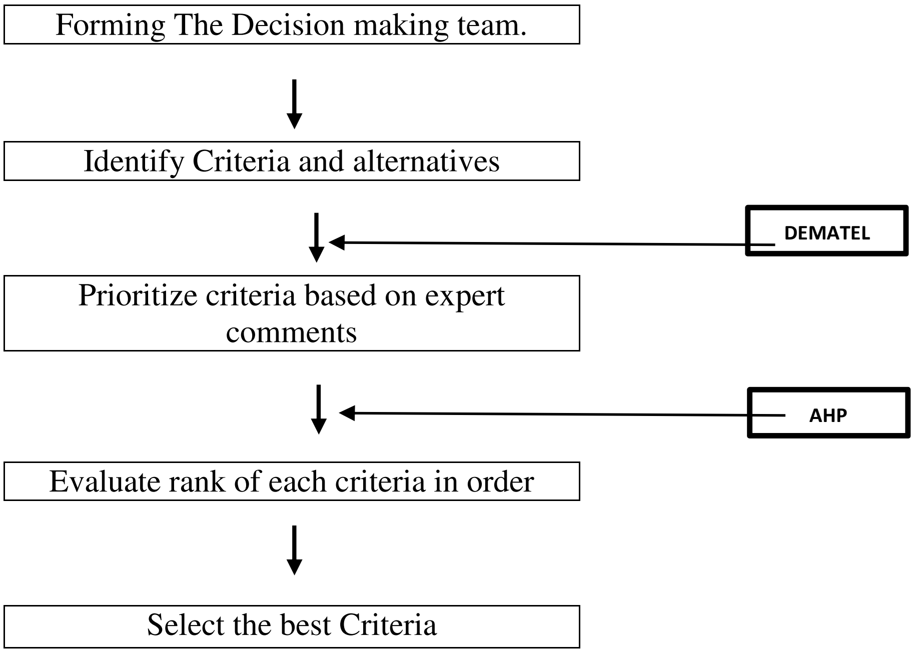

Figure3: An Integrated DEMATEL and AHPApproach for Personnel Estimation

7.0 CONCLUSION

Many MCMD methods have been introduced and applied in various field of studies in last several decades. This paper assessed the common methods of MCDM in order to help experts, consultants or practitioners to choose a method for solving specific problem. Identifying the weaknesses and strengths of each of MCDM models is a major step in creating the foundation of research in this area as the first step. As current researchers improved DEMATEL by identify the weaknesses by proposing new hybrid models such as Expanded DEMATEL that provide solution for complex feasible and infeasible issues or all kinds of networks that are inclusive bidirectional relations because of determining cause and effect factor to improve the system. The new formulations provide a more comprehensive approach for those application

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