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Evaluation of Job Offers using the Evidential Reasoning Approach

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Abstract

The word ?Job? term as a regular activity performed in exchange for payment is considered as one of the most important activities for many families worldwide .Evaluation is necessary when more than one opportunity come to an To fulfill their desired goal, it is the ?evaluation? which assesses among the factors. In addition, it is difficult to measure qualitative factors in a quantitative way, resulting incomplete-ness in data and hence, uncertainty. Besides it is essential to address the subject of uncertainty by using apt methodology; otherwise, the decision to choose a job will become inapt. There exist many methods name as Analytical Hierarchical Process (AHP), Analytical Network Process (ANP) and so on. But the mentioned methods are not suitable to address the subject of uncertainty and hence, resulting inappropriate selection to the expecting job. Therefore, this paper demonstrates the application of a novel method named Evidential Reasoning (ER), which is capable of addressing the uncertainty of multi-criterion problem, where there exist factors of both subjective and objective nature. The ER method handles uncertainties by using a belief structure is aggregating degrees of belief from lower level factors to higher level factors.

Index terms— multiple criteria decision analysis (MCDA), uncertainty, evidential reasoning (ER) and analytical hierarchy process (AHP).

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Reasoning Approach Tanjim Mahmud ? , Kazi Namirur Rahman ? & Dr. Mohammad Shahadat Hossain ? Abstract -The word "Job" term as a regular activity performed in exchange for payment is considered as one of the most important activities for many families worldwide .Evaluation is necessary when more than one opportunity come to an individual personality. Then it requires the job offer evaluation.

To fulfill their desired goal, it is the" evaluation" which assesses them well. This involves many factors to be measured and evaluated. These factors are expressed both in objective and subjective ways where as a hierarchical relationship exists among the factors. In addition, it is difficult to measure qualitative factors in a quantitative way, resulting incompleteness in data and hence, uncertainty. Besides it is essential to address the subject of uncertainty by using apt methodology; otherwise, the decision to choose a job will become inapt.

There exist many methods name as Analytical Hierarchical Process (AHP), Analytical Network Process (ANP) and so on.

But the mentioned methods are not suitable to address the subject of uncertainty and hence, resulting inappropriate selection to the expecting job. Therefore, this paper demonstrates the application of a novel method named Evidential Reasoning (ER), which is capable of addressing the uncertainty of multi-criterion problem, where there exist factors of both subjective and objective nature. The ER method handles uncertainties by using a belief structure is aggregating degrees of belief from lower level factors to higher level factors.

Keywords : multiple criteria decision analysis (MCDA), uncertainty, evidential reasoning (ER) and analytical hierarchy process (AHP).

hen we attempt to evaluate of job offers, it involves multiple criterions such as, location, salary, job content, long-term prospects, safety, and environment, proximity to hospitals, main road, office, transportation cost and utility cost, which are quantitative and qualitative in nature. Numerical data which uses numbers is considered as quantitative data and can be measured with 100% certainty. [4] Examples of quantitative data utility cost, transportation cost are the examples of quantitative data since they can be measured using number and with 100% certainty. On the contrary, qualitative data is descriptive in nature, which defines some concepts or imprecise characteristics or quality of things **??**5]. Hence, this data can"t describe a thing with certainty since it lacks the precision and inherits ambiguity, ignorance, vagueness. Consequently, it can be argued that qualitative data involves uncertainty since it is difficult to measure concepts or characteristics or quality of a thing with 100% certainty. Examples of qualitative data associated with in choosing a job are quality of location, safety and environment. "Quality of Location" is an example of equivocal term since it is an example of linguistic term. Hence, it is difficult to extract its correct semantics (meaning). However, this can be evaluated using some evaluation grade such as excellent, good, average and bad. Therefore, it can be seen that qualitative criterions which have been considered in selecting a job involves lot of uncertainties and they should be treated with appropriate methodology. There exists a number of techniques to handle multi-criterion problems such as AHP (Analytical hierarchy process), ANP (Analytical network process) and IPV (inner product vector) approach [8] [9]. These approaches use a pair wise comparison matrix in order to identify the importance between two attributes or data. For example, whether the quality of location is more important than environment [16] [17]. By applying pair wise comparison method we are able to calculate the weight of these two attributes, for example they can be 0.59 for location and 0.41 for safety. It can be seen that both are qualitative data. However, the calculation of such weight of the attributes is unable to address the problem of incompleteness or vagueness. If a belief structure is used taking account of evaluation grade of the attribute this incompleteness may be addressed and hence the uncertainty. Moreover, when we add another attribute, for example environment with location and safety it can be seen that the ranking of the attributes in terms of their importance will be changed. These types of problems associated with AHP [8] and ANP causes serious problems in decision making. The issues as mentioned can be addressed by using Evidential Reasoning Approach (ER), which is a multi-criteria decision analysis (MCDA) method [13] [14]. ER deals with problems, consisting of both quantitative and qualitative criteria under various uncertainties such as incomplete information, vagueness, ambiguity [7].The ER approach, developed based on decision theory in particular utility theory [1] [21], artificial intelligence in particular the theory of evidence [18] [19]. It uses a belief structure to model a judgment with uncertainty. For example, in AHP

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approach the importance of the attribute location and safety has been calculated as 0.51 and 0.49 respectively. However, such calculation of importance of the attributes contains uncertainty. The reason for this is that qualitative attribute such as location or safety needs to be evaluated using some linguistic evaluation grades such as excellent, average, good and bad etc. This requires human judgment for evaluating the attributes based on the mentioned evaluation grades. In this way, the issue of uncertainty can be addressed and more II.

3 Evidential Reasoning Approach

The evidential reasoning algorithm is considered as the kernel of the ER approach. This algorithm has been developed based on an evaluation analysis model [22][23] and the evidence combination rule of the Dempster-Shafer (D-S) theory [15][18] [19], which is well-suited for handling incomplete uncertainty [22]. The ER approach uses a belief structure to model an assessment as a distribution. It differs with other Multi Criteria Decision Making (MCDM) modeling model a judgment with uncertainty. For example, in AHP methods in that it employs evidence-based reasoning process to derive a conclusion [13][14] [20]. The main strength of this approach is that it can handle uncertainties associated with quantitative and qualitative data, related to MCDM problems [13][14] [20].

The ER approach consists of five phases[27] including 1) Information acquisition and representation or assessment, 2) weight normalization, 3) basic probability assignment 4) attribute aggregation, 5) Combined degree of belief calculation, 6) utility function 7) ranking.

4 a) Assessment

One of the critical tasks of developing a decision support system is to acquire information and to represent them in appropriate format so that it will feed into a model. Since ER approach employs belief structure to acquire knowledge, appropriate information should be selected to feed the ER algorithm, which is used to process the information.

Let 'Job evaluation' (S) be an attribute at level 1 as shown in Fig. 1, which is to be assessed for an alternative (A) (i.e. a job at a certain location) and this assessment can be denoted by A(S). This is to be evaluated based on a set of w i sub-attributes (such as facilities, cost, general) at level 2, denoted by: } ,..... .. ,..... , , { Job evaluation (S) can be assessed by using a set of evaluation grades consisting of Excellent (H 1), Good (H 2), Average (H 3), Bad (H 4) accurate and robust decision can be made.

The ER approach has addressed such issue by proposing a belief structure which assigns degree of belief in the various evaluation grades of the attributes, which is not the case in AHP in other multi-criterions decision techniques.

In section 2 will briefly represent ER algorithm. Section 3 will demonstrate the application of ER in job evaluation problem. Section 4 will represent the results and achievement. Finally section 5 will conclude the research. ? and this assessment can be represented as} ,....., 1 ,....., 1), , {( ) (, n i and N n H w A i n n i ? ? ? ? Such that 0 , ? i n ? and 1 1 ? ? ? N n n ? .

The incompleteness as mentioned occurs due to ignorance, meaning that belief degree has not been assigned to any specific evaluation grade and this can be represented using the equation as given below.? ? ? ? N n n H 1 1 ? ? (1)

Where H ? is the belief degree unassigned to any specific grade. If the value of H ? is zero then it can argued that there is an absence of ignorance or incompleteness. If the value of H ? is greater than zero then it can be inferred that there exists ignorance or incompleteness in the assessment. The ER algorithm, as will be discussed, has the procedures to handle such kind of ignorance. It is also necessary to distribute the degree of belief between evaluation grades for certain quantitative input data. For example, sub-attribute "proximity to hospital", which is at the level 3 of the Fig. 1, consists of four evaluation grades namely Excellent, Good, Average and Bad. When the hospital is located within 1km of the job place, it is considered as excellent, when it is located within 1.5km of the place it is considered as good, when it is located within 2 km of the place it is considered as average and when it is located within 3 km of the place it is considered as bad. However, when a hospital is located 1.3 km of the place, it can be both excellent and average. However, it is important for us to know, with what degree of belief it is excellent and with what degree of belief it is average. This phenomenon can be calculated with the following formula.i n i n i n n n i n h i h h h , , 1 , 1 1 , 1 , , ? ? ? ? ? ? ? ? ? ? ? ? , 1 , i n i n h h h if ? ? ?

Here, the degree of belief excellent. The value of h n+1 is the value related to excellent, which is considered as 1km i.e. the location of the hospital. The value of 1 ? n h is related to average, which is 1.5 km. Hence, applying equation (2) the distribution of the degree of belief with respect to 1.3 Km of the location of the hospital from the job place can be assessed by using equation (**??**) and the result is given below:

{(Excellent, 0.4), (Good, 0.6), (Average, 0), (Bad,0)}, b) Weight Normalization

The identification of the importance of the attributes is very important, since each attribute does not play the same role in decision making process. For example, the sub-attribute of the "Facilities" attribute at level 2 consists of three attributes namely, proximity to main road, hospitals and office. It is important for us to know among three attributes which is the most important in evaluating their parent attribute "Facilities". This can be carried out by employing different weight normalization techniques such as Eigenvector, AHP, Pair wise comparison [8][9][16] [17]. In this research Pair wise comparison method has been considered for the normalization of the weights of the attribute by considering the following equations? ? ? j i i i i y y 1 ? ;i= 1??.j**(3)**? ? ? L i i 1 1 ? (4)

Equation (3) is used to calculate the importance of an attribute) (i w .This has been calculated by dividing© 2013 Global Journals Inc. (US)

Evaluation of Job Offers using the Evidential Reasoning Approach Equation (**??**) has been used to check whether the summation of the importance of all the attributes is within one i.e whether they are normalized.

5 c) Basic Probability Assignment

The degrees of belief as assigned to the evaluation grades of the attributes need to be transformed into basic probability masses. Basic probability mass measures the belief exactly assigned to the n-th evaluation grade of an attribute. It also represents how strongly the evidence supports n-th evaluation grade , ( ) (, , l i n i n i i n a w H m m ? ? ? """ ; ,....., 1 N n ? """""""""" , ..., ,..... 1 L i ? (5)

However, in case of hierarchical model, the basic probability mass represents the degree to which the i-th basic attribute supports the hypothesis that the top attribute y is assessed to n-th evaluation grade.

The remaining probability mass unassigned to any individual grade after the ith attribute has been assessed can be given using the following equation.? ? ? ? ? ? ? ? N n l i n N n i n i i H a w m H m m 1 , 1 , ,), (1 1) (? , ..., ,..... 1 L i ? (6) d) Kernel of ER Approach

The purpose of ER algorithm is to obtain the combined degree of belief at the top level attribute of a hierarchy based on its bottom level attributes, also known as basic attributes. This is achieved through an effective process of synthesizing/aggregating of the information. A recursive ER algorithm is used to aggregate basic attributes to obtain the combined degree of belief of the top level attribute of a hierarchy, which can be represented as} ,....., 1), , {( ) (N n H S A n n ? ? ?

. In this recursive ER algorithm, all the basic attributes are aggregated recursively in the following manner as shown in Fig. 2. In this Fig. 2 "Facilities" is considered as the top level attribute, which consists of three sub-attributes. The top level attribute "Facilities" can be denoted by w (i) such that i= 1, 2, 3,..n. This means at this level there could be other attributes. For example, in our case, this level consists of three attributes and the level is considered as second level as shown in Fig. 1. It is interesting to note that top level of Fig. 1 contains only one attribute and that can be denoted by So (Job evaluation) and has three sub-attributes at second level. For the top level attribute (S) the combined degree of belief needs to be calculated based on the second level attributes.

From Fig. 2 ? such that i=1?..n and j = 1?..L. Taking account of the basic probability assignment and remaining unassigned probability mass of three sub-attributes mass of 1 w matrix (1) has been developed as shown below. These bpa (such as m 11 , m 21 „etc and reaming unassigned bpa such M H1) have been calculated by using equations 5 and 6. Now it is necessary to aggregate the bpa of different sub-attributes. The aggregation is carried out in a recursive way. For example, the bpa of first subattribute attribute (which is shown in the first row of the matrix 1) is aggregated with the bpa of second subattribute. The result of this aggregation is illustrated in the first row of the matrix (2) and this can be considered as the base case of this recursive procedure since this will be used in the latter aggregation of the subattributes. This aggregation can be achieved by using the following equation, which will yield combined bpa (such as

6 Recursive Step

Basis Step

..., 1 , 1 1 1 1 1 ,) (,) 1 (?? L i m m K N n N n t t i t i I n i I

The aggregation of the third attribute is carried out with the resultant of the aggregation of the bpa of the first two attributes. In this way, the aggregation of the other attributes is carried out and finally, the combined aggregations of all the attributes are obtained. This phenomenon has been depicted in Figure 2, where the combined aggregation is obtained, which will be used to obtain the combined degree of belief for the second level attribute "facilities". Equation (**??**) represents the more generalized version of equation (**??**) ? ? ? ? 1 ,) (, 1 ,) (, 1 ,) (,) 1 ( ) 1 (, : ? ? ? ? ? ? ? ? ? i n i I H i H i I n i n i I n i I i I n n m m m m m m K m H (9)), (,) (,) (, ~i I H i I H i I H m m m ? ? , ..., ,......... 1 N n ? ? ? ? ? 1 ,) (, 1 ,) (, 1 ,) (,) 1 ( ) 1 (, : ? ? ? ? ? ? ? ? i H i I H i H i I H i H i I H i I i I H m m m m m m K m H ? ? ? ?, : 1 ,) (,) 1 ( ) 1 (, ? ? ? ? i H i I H i I i I H m m K m H ..? ?? I H I n I n I n I n (1) (2) (**10**) (11)(**12**)) (,) (, N n m m H L I H L I n n n ? ? ? ? (13) ? ? , 1 :) (,) (, L I H L I H H m m H ? ? ? Where) ,..... 1 (1 ,) 1 (, N n m m n I n ? ?**(**

7 ? ?

The recursive ER algorithm combines various piece of evidence on a one-by-one basis.

e) The Utility Function (Ranking Job) Utility function is used to determine the ranking of the different alternatives. In this research different job sector have been considered as the alternatives. Therefore, the determination of ranking of the alternatives will help to take a decision to decide the suitable job. There are three different types of utility functions considered in the ER approach namely: minimum utility, maximum utility and average utility. In this function, a number is assigned to an evaluation or assessment grade. The number is assigned by taking account of the preference of the decision maker to a certain evaluation grade. Suppose the utility of an evaluation grade ? ? ? N n l n n l a H u a y S u 1) ( ) ( ))) (((? The belief degree) (l n a

? represents the lower bound of the likelihood that l a is assessed to n H , whilst the corresponding upper bound of the likelihood is given by)) ( ) ((l H l n a a ? ? ?

The maximum, minimum and average utilities of l a can be calculated by:)), ( )) ( ) (( ) ( ) ( ) (1 1 max N l H l N n N n l n l H u a a H u a a u ? ? ? ? ? ? ? ? ?), ( ) ( ) ( )) ( ) (( ) (2 1 1 min n N n l n l H l l H u a H u a a a u ? ? ? ? ? ? ? ? . 2) ( ) ( ) (min max l l l average a u a u a u ? ? It is important that if 0) (1 ? H u , then) ( ))) (((min l l a u a y S u ? if all the original assessments)) ((l i a e S in the belief matrix are complete, then 0) (? l H a ? and). ( ) ( ) ( ))) (((min min l average l l l a u a u a u a y S u ? ? ?

It has to be made clear that the above utilities are only used for characterizing a distributed assessment but not for the aggregation of factors.

In the previous section, we have discussed about the ER method and how to implement it. Therefore, in this section we will look at the results from using this method on the different types of job. The ER approach for job evaluation consists mainly of four key parts, which are the identification of factors, the ER distributed modeling framework for the identified factors, the recursive ER algorithms for aggregating multiple identified factors, and the utility function [3] based ER ranking method which is designed to compare and rank alternatives/options systematically. Each part will be described in detail in above section. Job evaluation, can be described in two broad categories: the Objective attribute, and subjective attribute as shown in Fig. 1 and each attribute weights are W1=0.20,w2=0.20,w3=0.60,w11=0.33,w12=0.33,w13 =0.33,w21=0.70,w22=0.30,w31=0.05,w32=0.15,w33 =0.05,w34=0.2,w35=0.05,w36=0.5 Figure 3 shows the assessment grades defined by the decision maker for Level 3(Fig. 1). Shows the assessment distribution which must be done first by employing the transformation equation. Any measurements of quality can be translated to the same set of grades as the top attribute which make it easy for further analysis.

The assessments given by the Decision Maker (DM) in Figure 1 are fed into Decision support system (DSS) [25][26] and the aggregated results are yielded at the5main criteria level (Fig. 1). The assessment grades for each main criterion are abbreviated in Figure 3. The numbers in brackets show the degrees of belief of the DM that are aggregated from the assessments of the sub-criteria. One can rank the job for each criterion in

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The results in Figure 3. are also useful in that they indicate the weak and strong points of each alternative regarding the decision criteria applied. The DSS [25][26] provides a graphical display of the results presented in Figure **??**. The assessments in Figure 3 need to be propagated to the top level. The numbers under each grade indicate the aggregated assessments (or degrees of belief) of the DM. For instance, the results for job Acme Manufacturing (A) can be interpreted as follows: job Acme Manufacturing (A) is assessed to be 15% bad, 10% average, 23% good, and 52% excellent. The total degree of belief does not add up to one (or 100%) as a result of incomplete and/or missing assessments. The results in Figure **??**. are supported by decision support system(DSS). The job could be ranked in order of preference by comparing them with each other as in Fig. 3. However, a comparison may not be possible when job have very similar degrees of belief assigned to each grade. One way to solve this problem is to quantify the grades. There are several ways of quantifying grades. One of them is to assign a utility for each grade and then obtain an expected utility for each job. Then, jobs are ranked based on their expected utility [3]. In this research, the former approach is used. A number of hypothetical lottery type questions were presented to the DM in order to establish preference among grades. The following utilities are assigned to each grade: (Bad, 0.4), (Average, 0.7), (Good, 0.85) and (Excellent, 1). The total Degree of belief for each job in Figure **??** does not add up to one, because some of the assessments were incomplete and missing. For example, the total Degree of belief assigned to job alternative is 97%. That is, there is a 3% unassigned degree of belief. The DSS uses the concept of utility interval to characterize the unassigned Degree of belief (or ignorance) which can actually fall into any grade. The ER algorithm generates a utility interval enclosed by two extreme cases where the unassigned Degree of belief goes either to the least preferred grade (minimum utility) or goes to the most preferred grade (maximum utility). The minimum and maximum possible utilities of each alternative generated by the DSS [25] The job may be ranked based on the average utility but this may be misleading. In order to say that one job theoretically dominates another, the preferred job minimum utility must be equal or greater than the dominated job maximum utility. The ranking of job is as follows: Acme Manufacturing (A) > Creative Consulting (C)> Dynamic Decision Making (D) > Bankers Bank (B) This paper established the scheme of the application of this evidential reasoning to solve a multiple criteria job offers evaluation with uncertain, incomplete, imprecise, and/or missing information. From the results shown above, it is reasonable to say that the evidential reasoning method is a mathematically sound approach towards measuring the job quality as it employs a belief structure to represent an assessment as a distribution. This approach is quite different from the other Multi Criteria Decision Making model such as the Saaty "s AHP method which uses a pair wise comparison matrix [8][9][13 [14]. Hence, the ER method can handle a new attribute without recalculating the previous assessment because the attribute can be arranged or numbered arbitrarily which means that the final results do not depend on the order in which the basic attributes are aggregated. Furthermore, any number of new job alternative can be added to the assessment as it does not cause a "rank reversal" as in the Saaty"s AHP method [8][9][13 [14]. Finally, in a complex assessment as in the job quality appraisal which involved objective and subjective assessments of many basic attributes as shown in Figure 1, it is convenient to have an approach which can tackle the uncertainties or incompleteness in the data gathered. Therefore, the ER is seen as reasonable method for "quality job" evaluation. [1] [2] [3]

Figure 1: ?

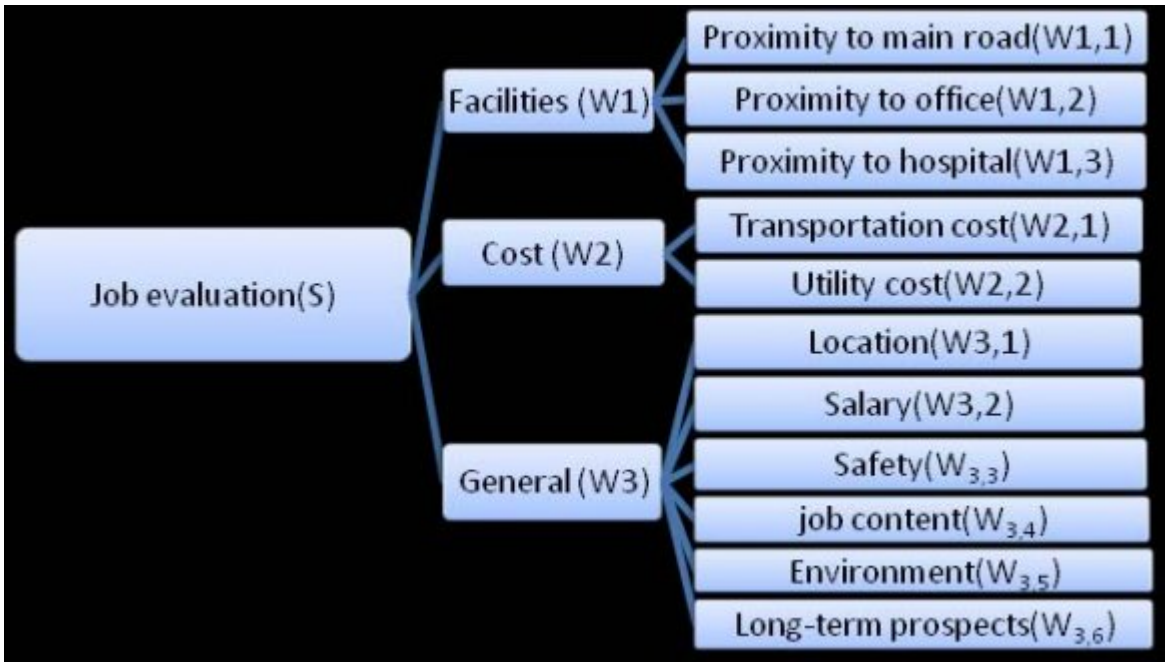
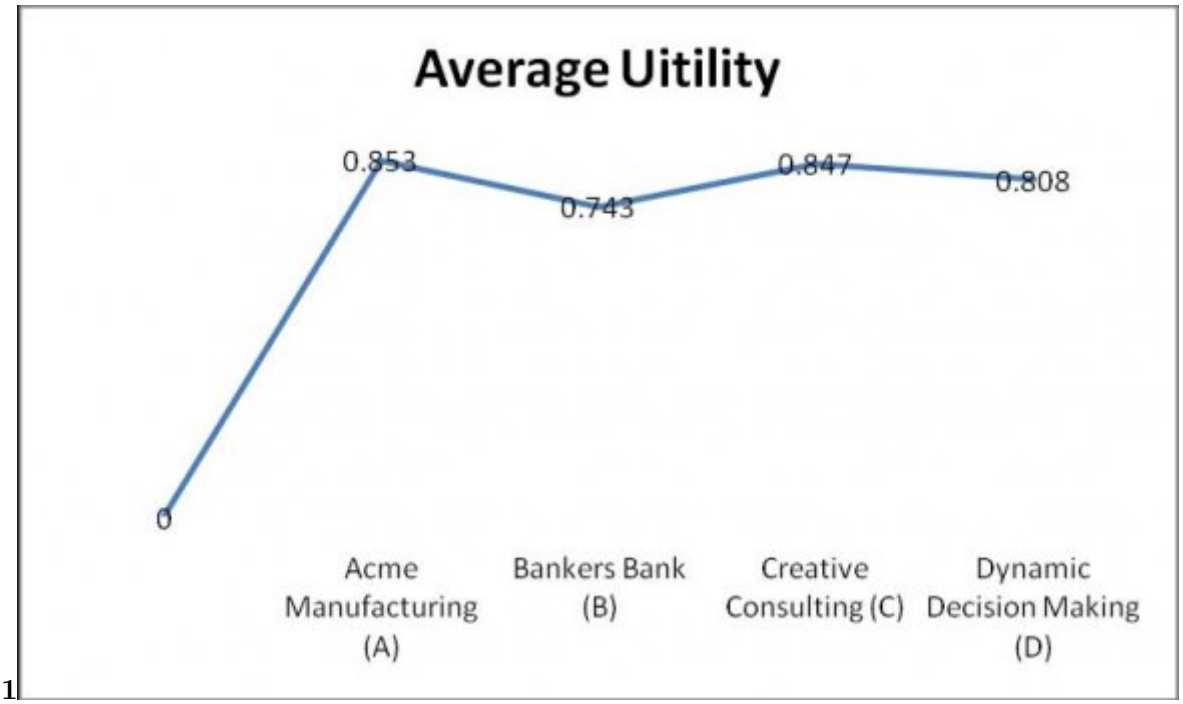


Figure 2:



1

Figure 3: 1 of

? n and H ? represent the belief degrees of th
aggregated assessment, to which the general factor
(such as ”facilities”) is assessed to the grade

H, respectively. The combined assessment can be denoted by ? ? ? ?. ,....., 1 ,) ( )) ((, N n a H a y S l n
It has been proved that 1 n ? H
?
?
N
n

Figure 4:

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[2] © 2013 Global Journals Inc. (US)Evaluation of Job Offers using the Evidential Reasoning Approach
[3] D © 2013 Global Journals Inc. (US)

Figure 5 : Overall Assessment For Acme Manufacturing (A)

Alternative	Attributes
	Ex-cel-lent
Location Acme Manufacturing (A)	0.14

Job Content Safety Bankers Bank (B) Environment Creative Consulting (C) Cost Dynamic Decision Making

Facilities Excellent (Dob-Degree of Belief)

Long-term Prospects Job Evaluation Alternative Transportation Cost Acme Manufacturing (A) Proximity t

Salary
Proximity to Main Road
Location
Job Content
Safety
Environment
Long-term Prospects
Proximity to Hospitals(Km)
Proximity to Office(Km)
Proximity to Main Road(Km)
Salary(Thousand)
Transportation Cost(Thousand)
Utility Cost(Thousand)

Figure 4 : Assessment Scores of Job Sector Based on Sub Criteria
(E-Excellent, G-Good, A-Average, B-Bad)

Figure 5:

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