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The suggestion of a decision making model

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Abstract

When the problems we face are complex and affect each other, then the decision making process is more difficult. In most cases we apply established policies or choices without knowing which the best choice is. To make appropriate decisions that can solve the problems encountered should be analyzed very well the reasons that create problems and their reciprocal influence. The mechanism that is mostly used in everyday decision making is based upon logic and experience. While in some decisions problems, instinct appears as a guide in the foreground, analytical structure of analytic hierarchy process enables feelings and instincts to organize and align with a shape that resembles human logic. Analytic structure of analytical hierarchy process enables feelings and instincts to organize and align with a shape that resembles human logic. Thus this analytical structure, gives people the opportunity to intervene in the most difficult and complex problems. This method is easily accessible and can be widely used in the banking system because of its dichotomous decisions.

Keywords: decision making, model, suggestion.

Introduction

Human intelligence during the decision-making process makes the decision by making a hierarchical analysis where they divide the problem into smaller parts (most important to least important). Analytic hierarchy process (AHP) in the way of solving problems uses a similar technique to human intelligence. People sometimes have difficulty facing complex problems in decision-making. The first solutions are known as inductive logic that is systematic, and the other one is practical logic deduction.
During the process of making a decision to understand the complexity of current system both inductive and deductive methods are used. The system facility which allows to merge these two approaches in an integrated system is Analytic Hierarchy Process (AHP-Analytical Hierarchy Process) (Thomas L. Saaty, 2000). In order to make a decision analytical hierarchy process is not only used by ordinary people but also from people who are competent leaders in the fields of economy and politics. According to sociologists mechanisms used to make decisions is divided in two types:

- Use of logic and experience;
- Use of instincts.

According to sociologists, rational thinking or decision making process is just a thin overlay on instinctive behavior (Thomas L. Saaty, 2000). People move in disorder and decide without being too confident when the elements that they need to analyze

are more. In most cases the people making decisions are directed by their simple instincts. Even when logic and / or calculations show the contrary, they choose to follow the path that tells instinct for making the decision. Instincts born of faith and the idea of thinking that can predict the future. Therefore decisions based on instincts can sometimes be more absurd.

Deduction and other methods that include due-end relationships can bring solutions in the decision-making process for simple problems. While terms of the most complex problems (consisting of qualitative and quantitative elements) remain insufficient. In case of problems formed by quantitative and qualitative elements we can use AHP as an effective technique to make decisions. AHP can help the receiver of the decision, having carefully mutual interaction and simultaneous many elements that are not part of the same structure and complex (framework) (Thomas L. Saaty, 2000).

AHP helps the decision of the people who will decide for the problem by taking a hierarchical structure evaluation, opinions, experiences and all information about this problem. This flexible structure enables analytical feelings and instincts to organize and align with a shape that resembles human logic. Thus this analytical flexible structure, allowes to adjust upon the paper instead of the mind, gives people the opportunity to intervene in the most difficult problems.

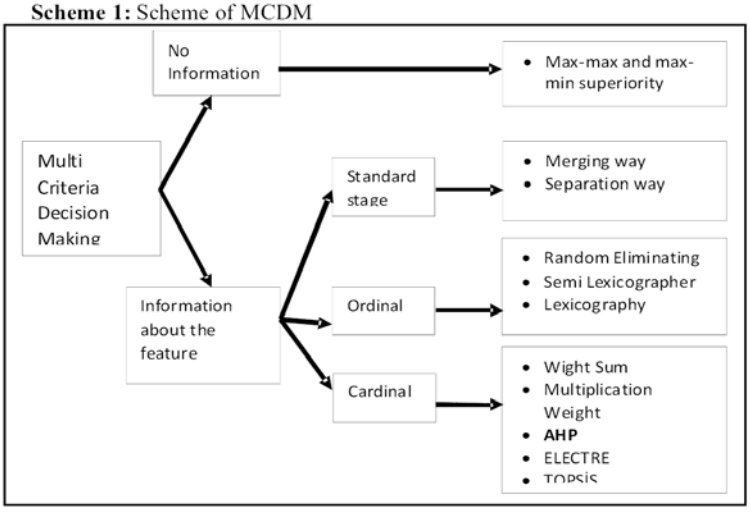
When trying to solve the problems using AHP, we face three phases:

- Presentation of complex mechanism of decision by a hierarchical structure;
- Determination of priorities;
- Calculation and evaluation of results (Partovi, F.Y, 1994).

The use of qualitative and quantitative elements in the decision-making mechanism

The solution of many problems in daily living is impossible to be achieved without the help of mathematics. In these kind of problems, decision-making system is used in a multiple way (MCDM Multi-Criteria Decision Making). One of the MCDM

Scheme 1: Scheme of MCDM



methods to assist in decision making in these kinds of problems is the AHP method.

Scheme 1: Scheme of MCDM

Source: *Evangelos Triantaphyllou, 2000, p.4.*

On the other side at AHP method must be found such a criteria to connect qualitative values with quantitative values and judgments made. This rating measure which make the connecting between mathematics and qualitative judgments is like a common type of language used to understand people who speak two different languages. That gives the opportunity to express their feelings about the numbers with a problem.
The truth is that the problems in life have a complex structure and therefore there are quantitative elements as well as qualitative inside them. For this reason, the first thing that should have to make the person who will take the decision in order to use the mathematical model is to return the qualitative judgments in numbered expression.

Analytical Hierarchy Process (AHP)

AHP is built on personal values and judgments of human logic. AHP create hierarchy based on imagination, experience and information. While making a judgment it used logic, instinct and experience (Thomas L. Saaty, 2000).
AHP method is simple to use and to be applied to the problems we face. Because the method is sensitive to the opinions and considering the attitude of decision makers to the problem, it enables decision making out of all thoughts, and not to make decisions according to formulas petrified about problems encountered (Thomas L. Saaty, 2000). AHP method has a structure that simplifies complex problems. It allows decision makers to determine a fairly preferences about his intentions. Being that it is susceptible to analysis, it helps the decision maker to take a more flexible decision (Ayşe Kuruüzüm ve Nuray Atsan, 2001).
AHP requires absolute unity of the double estimates and judgments (Nir Keren, 2003). AHP reaches a conclusion with the synthesis of different trials.

Mathematical tools used in AHP method

In economic science, mathematics models is one of the most important elements. Any economic model does require the need of mathematical application. AHP method indisputably is also in need of math. Matrix and the classification rate are two important tools of mathematics to science in AHP method.

Numerical scale used in twain comparison

When we compare two elements that are part of the matrix, we make an assessment of the elements which is better and more convenient than the other. In qualitative evaluations (good, very good, very very good, and perfect) language that fits with mathematical numbers was developed by Thomas L. Saaty and as shown in **Table 1** in the language depending on the importance of the element, numerical values from 1 to 9 expressed by a numerical value for each quality.
Table 1: *Rating Scale*

Significance Level	Definition	Explanation
1	Same Value	Both factors contribute equally in order
2	Weak	
3	Average Value	In the outcome of the experience and judgment a factor is more preferably that another factor
4	Average Plus	
5	Important Value	In the outcome of the experience and judgment a factor is a little more preferably that another factor
6	Important Plus	
7	Very Strong Importance or Pompous	A factor is much more preferably or his superiority was confirmed in practice
8	Very Very Strong	
9	Highest Level Importance	High opportunity to prove the fact that an important factor is preferable to another
2, 4, 6, 8	Intermediate values between two related degree	Used when necessary to achieve a compromise.

Source: *Thomas L. Saaty, (1980:54)*

Using a scale with nine figures offers a better way in the application evaluation (Thomas L. Saaty, 2000). According to the scale the same elements have the same level of importance value determined by the degree of a level above. The rate is used in qualitative evaluations as social, psychological, political.

The Use of Matrix

Hierarchical structure should have a structure that allows the comparison of elements. So they will assess all the information provided by the elements. Hierarchical structure at the same time must enable information and judging coherence between elements. Matrix is the mathematical tool which allows the development of this process. Matrix has a structure that makes possible the twain comparison. While working with AHP method, things that we should be careful when using the matrix are as follows:

- Matrix to be used in AHP model includes only elements of the same level or the same class.
- Twain Comparing that will be done in a matrix it must be turned by a criterion that is above and this criterion should be set on a corner of the matrix.
- Matrix should be definitely square matrix type N x N.
- It should provide all possible combinations of elements that will be evaluated in the matrix. So n_{ji} and n_{ij} made two estimates for elements (j) und (i) which are in the matrix. In the first evaluation is seen how important is element (i) compared with item (j) and the second comparison shows how important is element (j) compared with item (i). The conclusions of two evaluations are totally opposite. If we express the mathematical numbers $n_{ij}=1/n_{ji}$.
- To participate elements in the matrix as (i, j, k, g ...) when compared with the mathematical outcome itself will be 1. That $n_{ii} = 1$, $n_{jj} = 1$, $n_{kk} = 1$ etc. When the same elements face each other in the matrix as the diagonal of the matrix they are generally figure is 1.

- Once the matrix formed and positioned all the elements, twain evaluation begins. When we make twain comparison normally start from the element located in the left column and make comparison with the evaluation of elements of the same row. In this assessment on the basis of a criterion indicates that whenever the strongest element in this column compared with elements of the row.

Proximity to the truth of solutions with AHP method

Four conditions must be met that the solutions offered to solve the problem by AHP method be closer to the truth. These terms are reciprocity, homogenization, logical and continuity of the union (SAATY, Thomas L, 1994).

Reciprocity

As the need of the matrix twain comparison structure, comparison of elements w_i and w_j is done twice. At first it evaluates how many times the element w_i is important by element w_j then evaluate how much more the element w_i is important by element w_j.

$$a_{ij} = \frac{1}{a_{ji}} = \left(a_{ji}\right)^{-1}$$

Homogeneity condition

Homogeneous elements belonging to a particular class should be grouped together. So comparisons can be made between homogeneous elements and most importantly indicative table can be used to set numerical rating from 1 to 9. Since all the elements included in two comparisons, higher limit and lower limit (K) reads:

$$\frac{1}{K} \le a_{ij} \le K$$

$$K > 0 \quad (i, j = 1..n)$$

Near consistency

As indicated above, the homogeneity of the elements to be included in the twain comparing influences the consistency of the matrix. On the other hand because the matrix is the result of a certain rating, it expresses the implemented opinion or the consistency of present residence.

$$a_{ik} = a_{ij} \cdot a_{jk}$$

$$a_{ij} = \frac{1}{a_{ji}}$$

$(W_i = 2W_j)$ dhe $(W_j = 3W_k)$ atëherë $(W_i = 6W_k)$

Variance of matrix should not exceed 10% (generally accepted 5% for n = 3 and 8 % for n = 4, for n ^{3}5 %10) (SAATY, Thomas L, 1994).

Uniform Continuity

Twain comparing matrix W_i (i = 1, 2 ... n), as a function of a_{ij} must be sensitive to small changes in a_{ij} so that the proportional value of W_i / W_j, produce good forecasts versus a_{ij}. Namely whether in the hierarchy formed in a matrix derived from no consistency and this condition is caused due to wrong assessment, to enable the consistency of the matrix the error in the assessment must be found and repair. These repairs are effective when W_i is sensitive to small changes in a_{ij}.

The formation of the hierarchy

AHP method starts with selection of options and criteria that will make up the hierarchy of decision making about the problem we have in focus (J. E. De Steiguer & Jennifer Duberstein & Vincent Lopes, 2003). Once the problem is identified, the desired decisions taken in connection with this problem are defined and these decisions are accepted as objectives. The target set at the highest peak of the hierarchy and then all of the elements belonging to the problem shared by level of importance and homogenization are conditioned by a level criteria specified above (Steiguer, Jennifer Duberstein & Vincent Lopes, 2003).

Formation of the twain comparison matrices

While using AHP method for the problems, to determine the approximate importance of the criteria and sub-criteria after the formation of hierarchical model, we must create twain comparison matrices (Sipahi S. & Berber A, 2002). The importance value of elements while twain comparing is defined according to the above level criteria.

$$A = \begin{bmatrix} a_{1} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{2} & \cdots & a_{2n} \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ \cdot & & & \cdot \\ a_{n1} & a_{n2} & \cdots & a_{n} \end{bmatrix}$$

Components on the diagonal of comparative matrix take the 1 (one) value because $i = j$. In this case the question item compared with itself. Comparison of elements become one by one taking in advance the level of importance of each of them.

Determination of the priority values in twain comparison

Comparative Matrix shows elements within a certain logic by level of importance. So double values in the matrix comparisons show the gravity value for each element priority, using mathematical manipulations. But for all relevance within elements,

namely to determine the distribution of importance in percentage, use the columns of vectors generated in the comparative matrix. So to determine all relevance criteria column vector formed with the number *n b* and *n* component (Kaan Yaralıoğlu, 2001). This vector is shown below:

$$B_i = \begin{bmatrix} b_{11} \\ b_{21} \\ . \\ . \\ . \\ b_{n1} \end{bmatrix}$$

In calculating the column vector *B* we can use formula number 2. That is the formula used in the twain comparison matrix, evaluation of every element in the same column is divided by total values which are in each column:

$$b_{ij} = \frac{a_j}{\sum_{i=1}^{n} a_j} \tag{2}$$

When you repeat the steps explained above in the values of other elements, we will have the so many *B* column vectors as the number of elements. When we collect according to the format of the matrix all the numbers *n* in the benefit column vector *B*, the shown below *C* matrix will form which is a normalized matrix.

$$C = \begin{bmatrix} c_{11} & c_{12} & \cdots & c_{1n} \\ c_{21} & c_{22} & \cdots & c_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ c_{n1} & c_{n2} & \cdots & c_{nn} \end{bmatrix}$$

Using normalized matrix *C* can obtain the value of the importance by percentages of types by elements. For this, as shown in the formula number 3, taken the arithmetic mean of the components of the lines formed in the normalized matrix *C* and derived vector from this column vector of *W* is called priority vector.

$$w_i = \frac{\sum_{j=1}^{n} c_j}{n} \tag{3}$$

Vector *W* is as shown below:

$$W = \begin{bmatrix} w_1 \\ w_2 \\ . \\ . \\ . \\ w_n \end{bmatrix}$$

Calculation of the consistency

Core calculation of CR based on AHP method to compare the number of elements with a coefficient (l) called fundamental value. To calculate the basic value of coefficient (l)

at the beginning it have to obtain column vector *D* which is obtained by multiplying the priority vector *W* with comparison matrix *A*.

$$D = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1n} \\ a_{21} & a_{22} & \dots & a_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ a_{n1} & a_{n2} & \dots & a_{nn} \end{bmatrix} x \begin{bmatrix} w_1 \\ w_2 \\ . \\ . \\ . \\ w_n \end{bmatrix}$$

As defined in the formula number 4, acquired basic value (*E*) for each element in the evaluation of reciprocal elements between column vector *W* and *D*. The formula number 5, which include the arithmetic average of these values gives value basic (l) in connection with the comparison.

$$E_i = \frac{d_i}{w_i} \quad (i = 1,2,...,n) \tag{4}$$

$$\lambda = \frac{\sum_{i=1}^{n} E_i}{n} \tag{5}$$

After the calculation of basic values (l) with the help of formula number 6 we can find Consistency Index (CI-consistency Index).

$$CI = \frac{\lambda - n}{n-1} \tag{6}$$

While in the last step of CI is obtained CR by dividing the standard adjustment value shown in Table 2 called random indicator (Random Index RI). In Table 2 is selected the value which correspond to the number of elements. For example, the value of RI to be used in a comparison with the 3 elements under table 2 will be 0:58.

Table 2: *Value of Random Index (RI)*

n	1	2	3	4	5	6	7	8	9	10	11	12	13
Treguesi i rastësishëm	0	0	0,58	0,9	1,12	1,24	1,32	1,41	1,45	1,49	1,51	1,48	1,56

Source: Oğuzlar, 2007, fq.127.

$$CR = \frac{CI}{RI} \tag{VII}$$

In cases where the estimated value of CR is less than 0.10 then is clear that the comparisons made by the decision maker are consistent. If the value of CR is greater

than 0.10 then we have an error in calculation method AHP or instability in the comparisons made by the decision maker.

Finding the importance of the distribution from percentages degree for each element

At this stage determined the distribution of importance from the degree of percentage rate for each element. Saying in other words, matrix procedures and one by one comparison will be repeated as many time as *n* number of elements. This time the dimensions of comparative matrix *G* to be used in the decision points for each element will be *m x m*. After each comparison procedure column vector S is obtained that shows the distribution of the importance degree and by percentage degree and decision points of the evaluated item by the dimension *m x l*. This column vector is shown below:

$$S_i = \begin{bmatrix} s_{11} \\ s_{12} \\ . \\ . \\ . \\ s_{m1} \end{bmatrix}$$

Distribution of the end points of the decision

At this stage of the decision matrix *K* with dimension *m x n* formed by the columns of the vector *S* with *n* pieces with dimension *m x l* explained above. The decision matrix shown as follows:

$$K = \begin{bmatrix} s_{11} & s_{12} & \dots & s_{1n} \\ s_{12} & s_{12} & \dots & s_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ s_{m1} & s_{m2} & \dots & s_{mn} \end{bmatrix}$$

In conclusion, when the decision matrix *W* is multiplied following the column vector (vector of priority) *S* we obtain a column vector *L* with *m* elements. Column vector *L* gives the percentage distribution of decision points. In other words the total value of the elements of the vector is 1. This distribution also provides the order of importance of the decision points.

$$L = \begin{bmatrix} s_{11} & s_{12} & \dots & s_{1n} \\ s_{12} & s_{12} & \dots & s_{2n} \\ . & & & . \\ . & & & . \\ . & & & . \\ s_{m1} & s_{m2} & \dots & s_{mn} \end{bmatrix} x \begin{bmatrix} w_1 \\ w_2 \\ . \\ . \\ . \\ w_n \end{bmatrix} = \begin{bmatrix} l_{11} \\ l_{12} \\ . \\ . \\ . \\ l_{m1} \end{bmatrix}$$

Method of Analytic Hierarchy Process is developed by passing through all the stages described above.

Conclusions

Formed models for decision making are necessary in structuring decisions. Structuring the way of making decisions and incusing them in a model, facilitates and draws an

enormous work of directors and executive seniors. These models become ever more complicated and implicate numerous and complex of mathematical manipulations. The implication of these complex manipulations makes them be accessible only from a certain level professionals. Their usability only by high qualified people makes this models high costly by training workers to become their intended use and in human resources, according to high paying personnel who can use them. Using models that are simple and flexible in adapting to economic and social change is a huge advantage. Pattern analysis of hierarchical process is one such model, low cost and easily understandable. Use of AHP model in decision making will not only bring speed and precision of the work but also would have a relatively low cost compared to other models that are very complicated.

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