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A comparative analysis of seventh party logistics using AHP and FAHP

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ABSTRACT

The aim of work is to investigate the important benefits and parameters of decision-making models in ever changing technological world of business. Decision making models are helping function for decision makers to make future objectives by using qualitative and quantitative data. In the present research work is a general idea about MCMD and comparison between two models. Analytical Hierarchy Process (AHP) and Fuzzy Analytical Hierarchy Process (FAHP) are used in the selection of a seventh party logistics (7pl) and a comparative analysis is resulted. MCMD is used with many complex problems, in the present paper seventh party logistics service providers are based on the selection of criteria's and sub criteria. Decision makers can use this paper for choosing the suitable 7pl required their operations.

Keywords— *Analytical Hierarchy Process (AHP), Fuzzy Analytical Hierarchy Process (FAHP), MCMD, Criteria's*

1. INTRODUCTION

Many complex problems are solved using MCMD process. The decision maker usually presents a complex system of inter-related factors such as objectives, outcomes of objectives, personals or group of people. Logistics management is one of such complex systems where the decisions makers face challenges in selecting the right service provider according to their needs.

Decision makers has to select the best based on the characterization of different criteria's but situations are challenging to suit to specific need. Decision makers has to take into specific consideration for multiple criteria's. Two important methods are used in such satiations: Analytical Hierarchy Process (AHP) and Fuzzy Analytical Hierarchy Process (FAHP). Other methods of MCMD can also be used like Analytical Network Process (ANP), Elimination and Choice Translating Reality (Electre), Integrative structural Modeling (ISM),Technique for order preference by similarity to ideal solution (TOPSIS) etc. ,the present work results in conceptual model and hypothesis for developing a model to suit the needs of the logistics and services of the providers.

Steps recognized by decision makers for specific need:
1. Identify the problem,
2. Gather data required for the development of model,
3. Analyze using specific models,
4. Frame alternatives that suit the objective and help in functions.

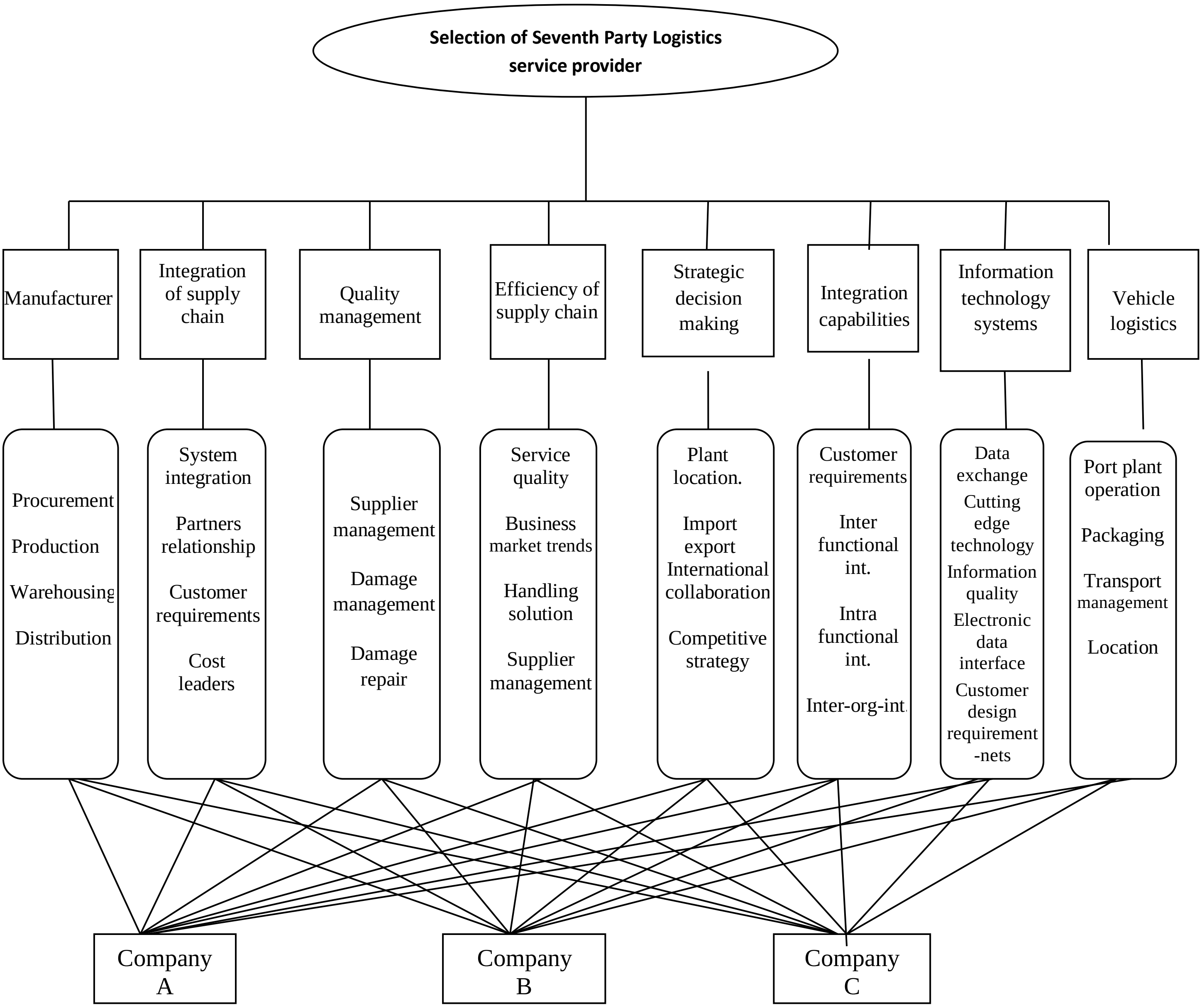

Fig. 1: Selection of Seventh party logistics service provider

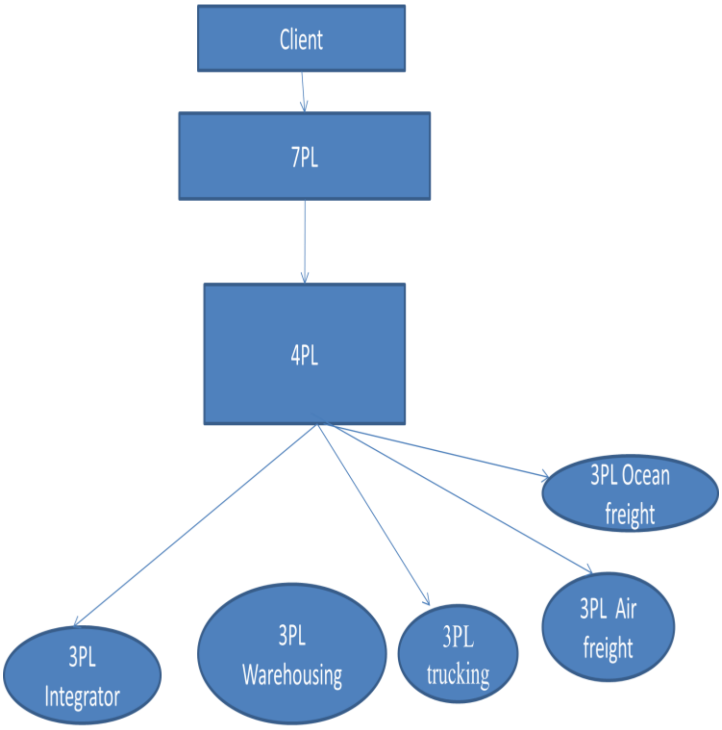

Fig. 2: Structure of Seventh party logistics provider

2. ANALYTICAL HIERARCHY PROCESS (AHP)

Thomas L. Saaty, first introduced analytical hierarchy process as a multi criteria decision making problems. It can be used to solve complicated decisions and factors in many real time situations and as its helps in dealing decision making. [7,9,10] He developed a scale for rating the criteria's on judgment scale. After rating, each of the criteria specific preference for decision alternatives are found for criteria's [5, 11]. AHP results in prioritized ranking to make decision in output as desired by the decision maker [2]. The decision-maker compares the items in terms of a continuous, 9-point, stimulus-centered judgment scale:

3. FUZZY ANALYTICAL HIERARCHY PROCESS (FAHP)

As the complexity of the problem increases in multi criteria decision making, in real time situations of ambiguity and vagueness, we have to deal with fuzziness and uncertainty. FAHP can be widely used under such conditions. FAHP is very useful in fuzzy environments, which is found to be substantial in recent years of applications. FAHP requires scientific approach to derive the weights from fuzzy pair wise comparison matrices. Fuzzy Extent Analysis Different methods have been proposed in the literatures. One of the most known of them is Fuzzy Extent Analysis proposed by Chang [1,3].

Fuzzy sets - described the mathematics of fuzzy set theory-was a generalization of classic set theory, allowed the membership functions to operate over the range of real numbers (0, 1) [6]. This approach of FAHP resolves and results in crisp selection. A triangular fuzzy number is the special class of fuzzy number whose membership is defined by three real numbers, expressed as (l, m, u).

The triangular fuzzy numbers is represented as follows: In order to understand and apply fuzzy set theory further, some important definitions are reviewed firstly:

(a) A fuzzy set Ậ in a universe of discourse U is characterized by a membership function $u_A(x)$ that takes values in the interval (0, 1). $u_A(x)$ is assigned to express the membership of x to Ậ.
(b) The height of a fuzzy set is the largest membership value attained by any point. If the height of a fuzzy set is equal to one, i.e., $u_A(x)$ =1, it is called a normal fuzzy set.
(c) An α-cut of a fuzzy set Ậ is a crisp set Ậα that contains all the elements in U that have memberships values in Ậ greater than to α, that is Ậα = {x€ U $u_A(x) \geq \alpha$}
(d) Triangular Fuzzy Number A fuzzy number Ã must possess following properties:
    1. $u_{\tilde{A}}(x) = 0$ for all x ϵ (-∞ ,L];
    2. $u_{\tilde{A}}(x)$ is strictly increasing on (L, M);
    3. $u_{\tilde{A}}(x)$ =1 for x= M;
    4. $u\bar{A}(x)$ is strictly decreasing on (M ,U);
    5. $u_{\tilde{A}}(x)$ =0 for all x ϵ (U , ∞);

Let Ã be a triangular fuzzy number with a triplet (L, M, U). The membership can be defined as,

$$u_{\tilde{A}}(x) = (x - L)/(M-L); \quad L \leq x \leq M$$
$$= (U - x)/(U-M); \quad M \leq x \leq U$$
$$= 0. \quad \text{Otherwise}$$

The fuzzy inference process integrates the rules in fuzzy rule base and then implements a mapping from fuzzy set Ậ in the universe of discourse U to fuzzy set Ñ the universe of discourse V. Due to the input and output of a fuzzy system are real-valued numbers in most applications, one must construct interfaces, fuzzifier and defuzzifier, between the fuzzy inference process and the environment. The fuzzification process represents a process of mapping a real- valued x €U R^n to a fuzzy Ậ in U.

4. DEFUZZIFICATION PROCESS

Notably, α can be viewed as a stable or fluctuating condition (Hsu and Yang, 2000). The range of uncertainty is greatest when α=0. Meanwhile, the decision-making environment stabilizes when increasing a while, simultaneously, the variance for decision decreases. Additionally, α can be any number between 0 and 1. Besides while α =0 represents the upper bound U_1 and lower-bound L_1 of triangular fuzzy numbers and while, α=1 represents the geometric mean M_1 in triangular fuzzy numbers, λ can be viewed as the degree of a decision maker's pessimism. When λ is 0, the decision maker is more optimistic and thus, the expert consensus is upper bound Uij of the triangular fuzzy number. Conversely, when λ = 1, the decision maker is pessimistic, and the umber ranges from 0 to 1. However, in this study, value of α is taken as 0.5.

Furthermore, the evaluator can be based on their own judgment, and adopt a conservative or optimistic attitude when determining λ value. Where λ =0 represents the most pessimistic scenario. In this study it is decided to take the middle–road and assigned λ = 0.5.

$$(aij\alpha) = [\lambda \,.\, Lij\alpha + (1-\lambda) \,.\, Uij\alpha],$$
$$0 \leq \lambda \leq 1, \; 0 \leq \alpha \leq 1, \text{ where,}$$

Lijα = (Mij - Lij). α + Lij Uijα =Uij –(Uij – Mij).α Lijα represents the left end value of α-cup for aij and Uij represents the right end value of α-cup for aij.

5. METHODOLOGY

5.1 AHP Calculations

Construction of pair wise comparison matrix using a scale of relative importance

The relative importance between the two criteria (i.e.) is assigned an appropriate value using Saaty's scale [8]. The pair-wise comparison intensity of relative importance between two criteria can be established using Table 1.

Table 1: Saaty's scale (1980)

Intensity of relative importance	Definition
1	Equally preferred
3	Moderately preferred
5	Essentially preferred
7	Very strongly preferred
9	Extremely preferred
2,4,6,8	Intermediate importance between two adjacent judgments

Assuming M criteria, the pair-wise comparison of criterion I with criterion j gives a square matrix A^1_{MxM} where a_{ij} denotes the relative importance of the criterion I with respect to criterion j. In the matrix, $a_{ij}=1$ when i=j and $a_{ij}=1/a_{ij}$. When $i\neq j$

5.2 Steps in AHP

Normalizing weight (W_i) of each criterion

The relative normalized weight (W_i) of each criterion may be obtained by calculating the geometric mean of i^{th} row and normalizing the geometric means of the rows in the comparison matrix.

$$GM_i = (\Pi^M_{j=1} a_{ij})^{1/M}$$

and

$$W_i= GM_i / {}^M_{j=1}\sum GM_j$$

Calculation of eigen value matrix

Construct matrix A_3 and A_4 such that $A_3=A_1 x A_2$ and $A_4=A_3/A_2,$

Where,

$$A_2 = [W_1, W_2, \ldots\ldots\ldots, W_i, Wn]^T$$

Finding the maximum eigen value $\lambda_{max.}$

The maximum eigen value $\lambda_{max.}$ may be obtained by calculating the average of matrix A_4.

Calculation of the consistency index C.I.

The consistency index may be obtained by using the equation

$$C. I. = (\lambda_{max}-M)/(M -1)$$

The smaller the value of the C.I deviation from the consistency is less.

Calculation of the random index R.I.

R.I. may be obtained for the number of criteria used in the decision making

Calculation of the consistency ratio

Consistency ratio may be obtained from C.R. = C.I. /R.I.; usually a C.R. of 0.1 or less is considered as acceptable as it reflects an informed judgment which could be attributed to the knowledge of the analyst about the problem under the study.

Calculation of priority weight for each alternative.

The priority weight for each alternative can be obtained by multiplying matrix of evaluation ratings by the vector of attribute weight and summing overall attributes. Expressed in conventional mathematical notation [4];

Weighted evaluation for alternatives, k $=\sum^i_{i=1}$ (attribute weight x evaluation rating $_{ik)}$.

Where i= 1, 2,………, t.

T=total number of alternatives.

B-Priority Calculations by Fahp:

Evaluating various 7PL service providers includes following steps:

Step 1: Define evaluative criteria and sub-criteria for selection of best 7PL service provider.

Step 2: Establish a hierarchical structure. Step 1 and Step 2 are already performed in AHP.

Step 3: Establish the triangular fuzzy numbers based on experts group interviews, decision- makers opinion and questionnaire which was attached along with the questionnaire of AHP. Based on the questionnaire results by decision maker's the fuzzy Pair-wise Comparison Judgmental Matrices (PCJMs).

Step 4: Perform defuzzification using the formula. Performing similar operation on each PJCM, we get fuzzy aggregate pair-wise comparison matrix for each level.

Step 5: Calculate relative weights of the elements in each level. Each of these matrices is then translated into the corresponding largest Eign value problem and is solved to find the normalized and priority weights of each criterion. With the sum-approach, the normalized priority weights are determined. Consistency Ratio (CR) of each PCJM is calculated, which is compared with the rule-of-the-thumb value of CR (RCR). Rule of thumb value of CR is 10% or 0.1. If the calculated CR is well below the corresponding RCR, it clearly implies that the decision maker is consistent in assigning pair wise comparison judgements. Otherwise, the PCJMs are invalid and should be reassigned by the decision maker. If all the PCJMs pass the consistent inspection, we should use the normalized priority weights to calculate the evaluation of each integrated service provider.

Step 6: The weights obtained for each alternative (A, B and C) are same as that of performance evaluation by AHP.

Step 7: Combination of relative weights of the elements of each level to determine the synthesis value of each alternative. Thus, the values are obtained. From the final values, we can conclude that service provider.

6. RESULTS

From the AHP model it is observed that all the criteria influence the selection of the integrated or 7PL service providers, since there are no criteria falling in the autonomous region. Thus, the model developed will only help to have a basic understanding to select the best alternative, for which the Multi Criteria Decision Making (MCDM) techniques have to be applied to get the priority weights of the criteria. In the next stage, this study proposes an analytical approach for the selection of integrated or 7PL service providers. A systematic approach using AHP has been applied for 7PL service provider selection.

The proposed methodology of FAHP helps the decision makers to include both the qualitative and quantitative criteria in the evaluation process. Pair wise comparison using triangular fuzzy numbers help in reducing the vagueness and impreciseness which otherwise largely persist in any human judge mental decision. A systematic approach using FAHP has been applied for 7PL service provider selection. The results show that the model has the capability to be flexible and be applied in different types of industries to choose the 7PL service provider.

7. CONCULSION

Both AHP and FAHP result in identifying the best alternative among the given choices. Complex problems of current business trends can make use these methods for solution. AHP helps in resolution multi criteria problems where as FAHP helps in resolving fuzziness in complex problems. Application of both these methods, prove to solve many problems in areas such as supplier selection, customer needs, logistics management, use service providers etc. However, sensitivity analysis is needed in both the methodologies, to validate the results in MCMD problem.

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