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THE APPLICATION OF POTENTIAL METHOD IN DECISION MAKING FOR MULTI-ATTRIBUTE OF CATERING SERVICE COMPANIES

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Abstract: Analytic Hierarchy Process is a method used in structuring, measuring and synthesizing criteria, in particular ranking of multiple criteria in decision making problems. On the other hand, Potential Method is a ranking procedure that utilizes preference graph. Two nodes are adjacent if they are compared in a pairwise comparison whereby the assigned arc is oriented towards the more preferred node. In this paper, Potential Method is used to solve problems in catering service selection. The Potential Method is found to be comparable to Modified Fuzzy Logarithmic Least Square Method in weight determination.

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1. Introduction

The Analytic Hierarchy Process (AHP) proposed by Saaty [1] is widely used in Multi Criteria Decision Making (MCDM). It is a tool for weight estimation. Analytic Hierarchy Process has been used as decision tool in many sectors such as government [2], business [3], industry [4], healthcare [5], and education [6]. Analytic Hierarchy Process builds a hierarchy of decision items via comparison between each pair of items expressed in a matrix form. The comparison produces scores that measure the importance of each item. The determination of weight is important in AHP. Some of these approaches are Extent Analysis, Potential Method (PM), Least Square Method, Minimax Method and Absolute Deviation Method.

Extent Analysis is an approach used to determine fuzzy weights in AHP. According to Wang *et al.* [7], Extent Analysis was introduced to obtain crisp priority vector from a triangular fuzzy comparison matrix. Extent Analysis may assign a zero weight to some important decision criteria. However, in some cases, information from a fuzzy comparison matrix is not applicable for Extent Analysis, as it will lead to unsatisfactory results as reported in Aggarwal and Singh [8].

Fuzzy Logarithmic Least Square Method (FLLSM) was introduced to overcome the drawbacks of the Extent Analysis. The FLLSM was formulated as a constrained nonlinear optimization model. It can directly derive normalized triangular fuzzy weights for both complete and incomplete triangular fuzzy comparison matrix. The FLLSM can be used in solving complex MCDM problems. Wang *et al.* [9] suggested to use FLLSM to obtain triangular fuzzy weights from a triangular fuzzy comparison matrix in constrained nonlinear optimization model to produce fuzzy weight with narrow support intervals.

Potential Method was introduced by Čaklović [10]. The method has been further investigated and developed by Čaklović and his co-researchers [11], [12] and [13]. It is a simple and flexible method since it is based on oriented graph approach. It is also a ranking procedure that requires a preference graph as an input. The nodes of the preference graph represent alternatives. Two nodes are adjacent if they are compared in pairwise and the arc is oriented towards the more preferred node.

We can say that node a is more preferred than node b, in notation $a \geq b$

such that a is terminal (ingoing) node a and b is the initial (outgoing) node. We also say that a *leaves* b and b *enters* a.

2. Basic Definitions

Definition 1. [14] A fuzzy number is a function $A : R \rightarrow [0, 1]$ such that:
  (a) A is normal (there exists $x_0 \in R$ with $\mu_A(x_0) = 1$).
  (b) A_α is closed interval for all $\alpha \in [0, 1]$.
  (c) A_α is convex for all $\alpha \in [0, 1]$.
  Definition 2. [15] A triangular fuzzy number is a special case of a fuzzy number. It is defined by a triplet $\tilde{A} = (l, m, u)$. This representation is interpreted as a membership function $\mu_{\tilde{A}} : R \rightarrow [0, 1]$ such that

$$\mu_{\tilde{A}} = \begin{cases} x - l/m - l, & l \leq x \leq m, \\ u - x/u - m, & m \leq x \leq u, \\ 0, & otherwise. \end{cases} \tag{1}$$

A fuzzy comparison matrix with triangular fuzzy number is expressed by

$$\mu_{\tilde{A}} = (\tilde{a}_{ij})_{nxn} = \begin{bmatrix} (1,1,1) & (l_{12}, m_{12}, u_{12}) & \cdots & (l_{1n}, m_{1n}, u_{1n}) \\ (l_{21}, m_{21}, u_{21}) & (1,1,1) & \cdots & (l_{2n}, m_{2n}, u_{2n}) \\ \vdots & \vdots & \ddots & \vdots \\ (l_{n1}, m_{n1}, u_{n1}) & (l_{n2}, m_{n2}, u_{n2}) & \cdots & (1,1,1) \end{bmatrix}, \tag{2}$$

where $\tilde{a} = (l_{ij}, m_{ij}, u_{ij})$ and $a_{ij}^{-1} = (\frac{1}{u_{ji}}, \frac{1}{m_{ji}}, \frac{1}{l_{ji}})$ for $i, j = 1, ..., n$ with $i \neq j$.

2.1. Extent Analysis

Chang [15] proposed five steps for Extent Analysis in order to derive the priority of a fuzzy comparison matrix. First, sum up each row of $\tilde{A}$ by fuzzy addition:

$$RS_i = \sum_{j=1}^{n} \tilde{a}_{ij} = (\sum_{j=1}^{n} l_{ij}, \sum_{j=1}^{n} m_{ij}, \sum_{j=1}^{n} u_{ij}), \quad i = 1, ..., n, \tag{3}$$

where RS_i defines the row sum.
  Second, normalize the above row sums $RS_i, i = 1, ..., n$ by

$$\tilde{S}_i = \frac{RS_i}{\sum_{j=1}^{n} RS_j}$$

$$= \left(\frac{\sum_{j=1}^{n} l_{ij}}{\sum_{k=1}^{n} \sum_{j=1}^{n} u_{kj}}, \frac{\sum_{j=1}^{n} m_{ij}}{\sum_{k=1}^{n} \sum_{j=1}^{n} m_{kj}}, \frac{\sum_{j=1}^{n} u_{ij}}{\sum_{k=1}^{n} \sum_{j=1}^{n} l_{kj}} \right), \quad i = 1, ..., n. \quad (4)$$

Third, compute the degree of possibility for $\tilde{S}_i \geq \tilde{S}_j$ by

$$V(\tilde{S}_i \geq \tilde{S}_j) = \begin{cases} 1 & \text{if,} \quad m_i \geq m_j, \\ \dfrac{u_i - l_j}{(u_i - m_i) + (m_i - l_j)}, & \text{if} \quad l_j \leq u_i, \\ & i, j = 1, ..., n; \ j \neq i, \\ 0, & \text{otherwise,} \end{cases} \quad (5)$$

where $\tilde{S}_i = (l_i, m_i, u_i)$ and $\tilde{S}_j = (l_j, m_j, u_j)$.

Fourth, calculate the degree of possibility for $\tilde{S}_i$ over all the other $n - 1$ fuzzy numbers by

$$V(\tilde{S}_i \geq \tilde{S}_j : j = 1, ..., n; j \neq 1) = \min_{j = \{1, ..., n\}, j \neq 1} V(\tilde{S}_i \geq \tilde{S}_j), \quad i = 1, ..., n. \quad (6)$$

Finally, define the priority vector $W = (w_1, ..., w_n)^T$ of the fuzzy comparison matrix $\tilde{A}$ as

$$w_i = \frac{V(\tilde{S}_i \geq \tilde{S}_j : j = 1, ..., n; j \neq 1)}{\sum_{k=1}^{n} V(\tilde{S}_i \geq \tilde{S}_j : j = 1, ..., n; j \neq k)}, \quad i = 1, ..., n, \quad (7)$$

where w_i defines the weight

2.2. Modified FLLSM

Yuen and Lau [16] pointed out that Modified FLLSM derives priorities from fuzzy triangular matrix, $\tilde{A}$.

First, calculate local weights as the following form:

$$\text{Min } J = \sum_{i=1}^{n} \sum_{j=1, j \neq i}^{n} ((lnw_i^L - lnw_j^U - lnl_{ij})^2 + (lnw_i^M - lnw_j^M - lnm_{ij})^2$$
$$+ (lnw_i^U - lnw_j^L - lnu_{ij})^2), \quad (8)$$

subject to
$$\begin{cases} m_i^L + \sum_{j=1, j \neq i}^{n} w_j^U \geq 1 \\ m_i^U + \sum_{j=1, j \neq i}^{n} w_j^L \leq 1 \\ \sum_{i=1}^{n} w_i^M = 1 \qquad i = 1, ..., n. \\ \sum_{i=1}^{n} w_i^L + w_i^U = 2 \\ w_i^U \geq w_i^M \geq w_i^L > 0 \end{cases}$$

The optimum solution to the above model forms normalized fuzzy weights $\tilde{w}_i = (w_i^L, w_i^M, w_i^U), i = 1, ..., n$ to obtain the local fuzzy weights.

Second, calculate the global fuzzy weight by solving two linear programming models and an equation for each decision alternative.

$$w_{A_i}^L = \min_{W \in \Omega_w} \sum_{j=1}^{m} w_{ij}^L w_j, i = 1, ..., n.$$

$$w_{A_i}^U = \max_{W \in \Omega_w} \sum_{j=1}^{m} w_i^U w_j, i = 1, ..., n. \tag{9}$$

$$w_{A_i}^M = \sum_{j=1}^{m} w_{ij}^M w_j^M, i = 1, ..., n.$$

where $\Omega_w = \{W = (w_1, ..., w_m) | w_j^U \geq w_j^M \geq w_j^L, \sum_{j=1}^{m} w_j = 1, ..., m\}$ is a set of fuzzy weights.

2.3. Potential Method

Čaklović and Sego [11] used a preference graph to present their pairwise comparisons of a set of alternatives V. A pair $\alpha = (u, v) \in V \times V$ is declared to be an arc of a directed graph if v is more preferred than u. The set of arcs is denoted by A. A function $F : A \to \mathbb{R}$ which assigns to each arc $\alpha \in A$ as its weight is called a preference flow. A preference flow is always a non-negative and can be represented by $m \times 1$ matrix. A directed graph (V, A) is called a preference graph.

A preference graph is complete if each pair of alternatives is compared, i.e. if for each pair $\{i, j\}$ of vertices, then $(i, j) \in A$ or $(j, i) \in A$. For a given flow F a preference graph (V, A) with $\alpha \in A$ is written as $F(-\alpha) = -F(\alpha)$.

Let denote $n = \text{Card } V$ and $m = \text{Card } A$. An $m \times n$ incidence matrix of preference graph is denoted by B such that

$$B_{\alpha,i} = \begin{cases} -1, & \text{if } \alpha \quad \text{leaves} \quad i, \\ 1, & \text{if } \alpha \quad \text{enters} \quad i, \\ 0, & \text{otherwise.} \end{cases} \tag{10}$$

An example of a preference graph in grading process was considered by Bouyssou *et al.* as discussed in Čaklović [10].
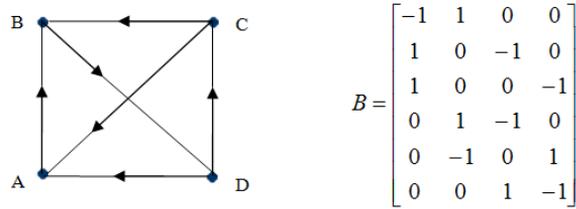
Figure 1: The preference graph and its incidence matrix.

In a hierarchical decision structure, each node except the last level is a parent node for its children from some other level. A parent node may be considered as the criterion for its children evaluation. The only restriction is that children of the parent should be in the same level. The conservation law restricts the sum of the weights of nodes in some level set, i.e. the sum of the weights of their parents.

Potential Method calculates the weights of nodes in some level in the following way. First, the weight of the goal is set to be 1. The aggregation of flows is made over the set of all parents if it is not ranked. Potential X is calculated after the weight w is obtained using the formula

$$w = k.\frac{a^X}{\|a^X\|_1},\tag{11}$$

where $\|.\|_1$ represents l_i-norm and k is the sum of weights of the parents (usually $k = 1$). Parameter a is chosen to be 2 as suggested by Čaklović [10]. The process is repeated until the bottom level of the hierarchy is ranked.

3. Implementation

In Wang *et al.* [7], a big Turkish textile company had to make a contract with one catering firm. Alternative catering firms were Durusu, Mertol and Afiyetle. In this study, the goal was to select the best catering firm among the alternatives. The criteria to be considered were hygiene (H), quality of meal (QM) and quality of service (QS). In order to make the selection, 11 sub criteria needed to be considered. The three sub criteria of H were hygiene of meal (HM), hygiene of service personnel (HSP) and hygiene of service vehicles (HSV). The variety of meal (VM), complementary meals in a day (CoM), calorie of meal (CaM) and taste of meal (TM) were four sub criteria of QM. The

four sub criteria of QS were behavior of service personnel (BSP), service time (ST), communication on phone (CP) and problem solving (PS) ability. The hierarchical structure of the problem is presented in Figure 2. A decision-making group consisting of the customers of the catering firms and five experts were responsible for making comparisons and constructing fuzzy comparison matrices.
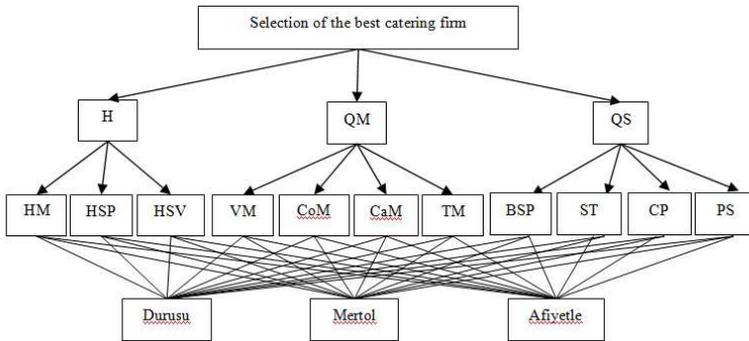
Figure 2: The hierarchy problem

The fuzzy comparison matrices in Table 1-15 are all taken from Wang *et al.* [7]. The fuzzy comparison matrix relevant to goal is given in Table 1. The PM is based on directed graph approach. Figure 3 illustrates the preference graph for the identified goal, whereby QS is more preferred than H and QM whereas H preferred over QM.
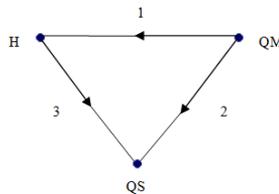
Figure 3: The preference graph-goal

The incidence matrix B and the potential X of goal are

$$\begin{pmatrix} 1 & -1 & 0 \\ -1 & 0 & 1 \\ 0 & -1 & 1 \end{pmatrix} \quad \text{and} \quad \begin{pmatrix} -0.667 \\ -1 \\ 1.667 \end{pmatrix}, \text{ respectively.}$$

The priority vector with respect to the goal, criteria and sub criteria are given in Table 1-15. The weights are determined via PM. The determined weights obtained from Wang *et al.* [7] by using Extent Analysis and Modified FLLSM are presented in these tables.

Criteria	H	QM	QS	Priority Vector		
				Extent Analysis	Modified F LLSM	Potential Method
H	(1,1,1)	(2/3,1,3/2)	(2/7,1/3,2/5)	0	(0.1781, 0.2098, 0.2477)	0.146
QM	(2/3,1,3/2)	(1,1,1)	(2/5,1/2,2/3)	0	(0.1933, 0.2402, 0.3015)	0.116
QS	(5/2,3,7/2)	(3/2,2,5/2)	(1,1,1)	1	(0.5302, 0.5499, 0.5990)	0.738

Table 1: Fuzzy comparison matrix of decision criteria with respect to goal and its priority vectors

Sub-Criteria	HM	HSP	HSV	Priority Vector		
				Extent Analysis	Modified F LLSM	Potential Method
HM	(1,1,1)	(2/3,2,5/2)	(2/7,1/3,2/5)	0.70	(0.4615, 0.5000, 0.5128)	0.055
HSP	(2/5,1/2,3/2)	(1,1,1)	(2/5,1/2,2/3)	0.15	(0.2051, 0.2500, 0.3077)	0.044
HSV	(5/2,3,7/2)	(2/3,1,3/2)	(1,1,1)	0.15	(0.2051, 0.2500, 0.3077)	0.047

Table 2: Fuzzy comparison matrix of sub-criteria with respect to hygiene and its priority vectors

Tables 16-18 show the local weights for criteria H, QM and QS for Extent Analysis, Modified FLLSM and the PM. The global weights for goal can be referred in Table 19.

Table 19 summarizes the weight for the three catering firms. The weight of Afiyetle obtained by Extent Analysis is 0.317, while Modified FLLSM and PM give 0.4072 and 0.437, respectively. The weights for Durusu are 0.3096 and 0.286 by using Modified FLLSM and PM. The weight for Durusu is 0.050 by using Extent Analysis and 0.634 for Mertol. This weight is slightly higher

| Sub-Criteria | VM | CoM | CaM | TM | Priority Vector | | |
					Extent Analysis	Modified F LLSM	Potential Method
VM	(1,1,1)	(3/2,2,5/2)	(2/7,1/3,2/5)	(5/2,3,7/2)	0.19	(0.2188, 0.2488, 0.2783)	0.030
CoM	(2/5,1/2,2/3)	(1,1,1)	(2/7,1/3,2/5)	(7/2,4,9/2)	0.05	(0.1729, 0.1890, 0.2107)	0.028
CaM	(5/2,3,7/2)	(5/2,3,7/2)	(1,1,1)	(5/2,3,7/2)	0.76	(0.4371, 0.4768, 0.5095)	0.034
TM	(2/7,1/3,2/5)	(2/9,1/4,2/7)	(2/7,1/3,2/5)	(1,1,1)	0	(0.0815, 0.0854, 0.0911)	0.024

Table 3: Fuzzy comparison matrix of sub-criteria with respect to quality of meal and its priority vectors

| Sub-Criteria | BSP | ST | CP | PS | Priority Vector | | |
					Extent Analysis	Modified F LLSM	Potential Method
BSP	(1,1,1)	(2/9,1/4,2/7)	(7/2,4,9/2)	(2/7,1/3,2/5)	0	(0.1408, 0.1493, 0.1597)	0.078
ST	(7/2,4,9/2)	(1,1,1)	(7/2,4,9/2)	(5/2,3,7/2)	0.99	(0.4826, 0.5173, 0.5472)	0.465
CP	(2/9,1/4,2/7)	(2/9,1/4,2/7)	(1,1,1)	(2/7,1/3,2/5)	0	(0.0707, 0.0747, 0.0802)	0.028
PS	(5/2,3,7/2)	(2/7,1/3,2/5)	(5/2,3,7/2)	(1,1,1)	0.01	(0.2321, 0.2587, 0.2866)	0.167

Table 4: Fuzzy comparison matrix of sub-criteria with respect to quality of service and its priority vectors

than the weight obtained from Modified FLLSM (0.2831) and PM (0.277) for Mertol.

Modified FLLSM and PM produce the same rank in selection of the best catering firm. The Modified FLLSM and PM indicate that the highest is Afiyetle followed by Durusu and the lowest is Mertol. However, Extent Analysis found Mertol is the best firm, followed by Durusu, with Afiyetle as the worst.

Mertol is found to be the best catering firm by using Extent Analysis

Catering Firms	Durusu	Mertol	Afiyetle	Priority Vector		
				Extent Analysis	Modified F LLSM	Potential Method
Durusu	(1,1,1)	(5/2,3,7/2)	(3/2,2,5/2)	0.66	(0.4668, 0.5278, 0.5760)	0.020
Mertol	(2/7,1/3,2/5)	(1,1,1)	(2/7,1/3,2/5)	0	(0.1343, 0.1396, 0.1476)	0.017
Afiyetle	(2/5,1/2,2/3)	(5/2,3,7/2)	(1,1,1)	0.34	(0.2897, 0.3325, 0.3857)	0.019

Table 5: Fuzzy comparison matrix of three catering firms with respect to hygiene of meal and its priority vectors

Catering Firms	Durusu	Mertol	Afiyetle	Priority Vector		
				Extent Analysis	Modified F LLSM	Potential Method
Durusu	(1,1,1)	(2/3,1,3/2)	(2/9,1/4,2/7)	0	(0.1592, 0.1840, 0.2127)	0.014
Mertol	(2/3,1,3/2)	(1,1,1)	(2/5,1/2,2/3)	0	(0.1867, 0.2318, 0.2906)	0.014
Afiyetle	(7/2,4,9/2)	(3/2,2,5/2)	(1,1,1)	1	(0.5502, 0.5842, 0.6006)	0.016

Table 6: Fuzzy comparison matrix of three catering firms with respect to hygiene of service personnel and its priority vectors

Catering Firms	Durusu	Mertol	Afiyetle	Priority Vector		
				Extent Analysis	Modified F LLSM	Potential Method
Durusu	(1,1,1)	(2/3,1,3/2)	(2/7,1/3,2/5)	0	(0.1781, 0.2098, 0.2477)	0.015
Mertol	(2/3,1,3/2)	(1,1,1)	(2/5,1/2,2/3)	0	(0.1933, 0.2402, 0.3015)	0.015
Afiyetle	(5/2,3,7/2)	(3/2,2,5/2)	(1,1,1)	1	(0.5203, 0.5499, 0.5590)	0.017

Table 7: Fuzzy comparison matrix of three catering firms with respect to hygiene of service vehicles and its priority vectors

whereby Mertol is identified as the worst firm selected by Modified FLLSM and PM. The weight of Mertol is higher by Extent Analysis as some important criteria were assigned as zero weight. Extent Analysis produced less preferable decision since some important criteria were neglected.

The Modified FLLSM and PM are appropriate methods to use in deriving priorities or weight of decision criteria, in contrast to Extent Analysis. However, Extent Analysis is a method that can show degree of priority for one criterion in a fuzzy comparison matrix.

Catering Firms	Durusu	Mertol	Afiyetle	Extent Analysis	Priority Vector Modified F LLSM	Potential Method
Durusu	(1,1,1)	(2/7,1/3,2/5)	(2/3,1,3/2)	0	(0.1805, 0.2223, 0.2670)	0.010
Mertol	(5/2,3,7/2)	(1,1,1)	(1,1,1)	0.97	(0.4566, 0.4566, 0.4566)	0.010
Afiyetle	(2/3,1,3/2)	(1,1,1)	(1,1,1)	0.03	(0.2764, 0.3211, 0.3629)	0.010

Table 8: Fuzzy comparison matrix of three catering firms with respect to variety of meal and its priority vectors

Catering Firms	Durusu	Mertol	Afiyetle	Extent Analysis	Priority Vector Modified F LLSM	Potential Method
Durusu	(1,1,1)	(5/2,3,7/2)	(2/3,1,3/2)	0.87	(0.3967, 0.4602, 0.5144)	0.010
Mertol	(2/7,1/3,2/5)	(1,1,1)	(1,1,1)	0	(0.2207, 0.2207, 0.2207)	0.009
Afiyetle	(2/3,1,3/2)	(1,1,1)	(1,1,1)	0.13	(0.2648, 0.3190, 0.3825)	0.009

Table 9: Fuzzy comparison matrix of three catering firms with respect to complementary of meal and its priority vectors

Catering Firms	Durusu	Mertol	Afiyetle	Extent Analysis	Priority Vector Modified F LLSM	Potential Method
Durusu	(1,1,1)	(2/9,1/4,2/7)	(2/7,1/3,2/5)	0	(0.1130, 0.1207, 0.1313)	0.011
Mertol	(7/2,4,9/2)	(1,1,1)	(2/7,1/3,2/5)	0.31	(0.2794, 0.3043, 0.3341)	0.011
Afiyetle	(5/2,3,7/2)	(5/2,3,7/2)	(1,1,1)	0.69	(0.5346, 0.5750, 0.6075)	0.012

Table 10: Fuzzy comparison matrix of three catering firms with respect to calorie of meal and its priority vectors

4. Conclusions

The aim of this study is to illustrate the application of PM to the problem posted in [7]. The comparison of weights from this study is compared to result obtained from Extent Analysis and Modified FLLSM. The PM and Modified FLLSM are found to be suitable approaches in determining criteria weights of AHP. The Extent Analysis is found less preferable in weight determination since it assigned a zero weight to some criteria.

| Catering Firms | Durusu | Mertol | Afiyetle | Priority Vector | | |
				Extent Analysis	Modified F LLSM	Potential Method
Durusu	(1,1,1)	(2/3,1,3/2)	(1,1,1)	0	(0.2731, 0.3126, 0.3849)	0.008
Mertol	(2/3,1,3/2)	(1,1,1)	(2/9,1/4,2/7)	0	(0.1604, 0.1966, 0.2361)	0.008
Afiyetle	(1,1,1)	(7/2,4,9/2)	(1,1,1)	1	(0.4908, 0.4908, 0.4908)	0.008

Table 11: Fuzzy comparison matrix of three catering firms with respect to taste of meal and its priority vectors

| Catering Firms | Durusu | Mertol | Afiyetle | Priority Vector | | |
				Extent Analysis	Modified F LLSM	Potential Method
Durusu	(1,1,1)	(7/2,4,9/2)	(5/2,3,7/2)	1	(0.6110, 0.6337, 0.6489)	0.029
Mertol	(2/9,1/4,2/7)	(1,1,1)	(1,1,1)	0	(0.1705, 0.1744, 0.1804)	0.024
Afiyetle	(2/7,1/3,2/5)	(1,1,1)	(1,1,1)	0	(0.1797, 0.1919, 0.2086)	0.025

Table 12: Fuzzy comparison matrix of three catering firms with respect to behavior of service personnel and its priority vectors

| Catering Firms | Durusu | Mertol | Afiyetle | Priority Vector | | |
				Extent Analysis	Modified F LLSM	Potential Method
Durusu	(1,1,1)	(3/2,2,5/2)	(2/7,1/3,2/5)	0.05	(0.2443, 0.2827, 0.3291)	0.138
Mertol	(2/5,1/2,2/3)	(1,1,1)	(7/2,4,9/2)	0.64	(0.3729, 0.4142, 0.4614)	0.190
Afiyetle	(5/2,3,7/2)	(2/9,1/4,2/7)	(1,1,1)	0.31	(0.2904, 0.2987, 0.3018)	0.138

Table 13: Fuzzy comparison matrix of three catering firms with respect to service time and its priority vectors

The Modified FLLSM and PM are found to be suitable approaches in determining the weight due to their ability to produce better weight than Extent Analysis. The PM is found to be comparable to Modified FLLSM. However, PM is found to be simpler to implement than Modified FLLSM.

Catering Firms	Durusu	Mertol	Afiyetle	Priority Vector		
				Extent Analysis	Modified F LLSM	Potential Method
Durusu	(1,1,1)	(7/2,4,9/2)	(2/3,1,3/2)	0.86	(0.4242, 0.4934, 0.5573)	0.010
Mertol	(2/9,1/4,2/7)	(1,1,1)	(2/3,1,3/2)	0	(0.1782, 0.1958, 0.2098)	0.009
Afiyetle	(2/3,1,3/2)	(2/3,1,3/2)	(1,1,1)	0.14	(0.2329, 0.3108, 0.3976)	0.009

Table 14: Fuzzy comparison matrix of three catering firms with respect to communication on phone and its priority vectors

Catering Firms	Durusu	Mertol	Afiyetle	Priority Vector		
				Extent Analysis	Modified F LLSM	Potential Method
Durusu	(1,1,1)	(1,1,1)	(2/9,1/4,2/7)	0	(0.1714, 0.1769, 0.1769)	0.047
Mertol	(1,1,1)	(1,1,1)	(2/7,1/3,2/5)	0	(0.1782, 0.1922, 0.2101)	0.049
Afiyetle	(7/2,4,9/2)	(5/2,3,7/2)	(1,1,1)	1	(0.6130, 0.6309, 0.6505)	0.072

Table 15: Fuzzy comparison matrix of three catering firms with respect to problem solving ability and its priority vectors

Catering	Priority Vector		
	Extent Analysis	Modified F LLSM	Potential Method
Durusu	0.462	(0.3055,0.3642,0.4089)	0.049
Mertol	0	(0.1612,0.1878,0.2280)	0.042
Afiyetle	0.538	(0.4082,0.4498,0.4919)	0.055

Table 16: Local weights of three catering firms with respect to hygiene

Catering	Priority Vector		
	Extent Analysis	Modified F LLSM	Potential Method
Durusu	0.044	(0.1910,0.2265,0.2673)	0.037
Mertol	0.420	(0.2950,0.3172,0.3406)	0.038
Afiyetle	0.537	(0.4043,0.4563,0.5027)	0.041

Table 17: Local weights of three catering firms with respect to quality of meal

Acknowledgements

Catering		Priority Vector	
	Extent Analysis	Modified F LLSM	Potential Method
Durusu	0.050	(0.2878,0.3258,0.3631)	0.221
Mertol	0.634	(0.2709,0.3047,0.3434)	0.244
Afiyetle	0.317	(0.3430,0.3696,0.3963)	0.273

Table 18: Local weights of three catering firms with respect to quality of service

Catering		Priority Vector	
	Extent Analysis	Modified F LLSM	Potential Method
Durusu	0.050	(0.2618,0.3096,0.3559)	0.286
Mertol	0.634	(0.2484,0.2831,0.3221)	0.277
Afiyetle	0.317	(0.3707,0.4072,0.5554)	0.437

Table 19: Global weights of three catering firms with respect to goal

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