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Multicriteria decision making in marketing mix on customer satisfaction using triangular intuitionistic fuzzy numbers (TIFNS)

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Abstract

This paper takes a cautionary stance to the impact of marketing mix on customer satisfaction, via a case study deriving consensus rankings for benchmarking on selected retail stores. Hungarian Triangular Intuitionistic Fuzzy model is used in deriving consensus rankings via multi criteria decision making method for benchmarking base on the marketing mix model 4Ps. Descriptive analysis is used to analyze the best practice among the four marketing tactics. Outranking methods in consequence constitute a strong base on which to found the entire structure of the behavioral theory of benchmarking applied to development of marketing strategy. This study has looked only at a limited part of the puzzle of how consumer satisfaction translates into behavioral outcomes. This paper interestingly portrays the effective usage of multicriteria decision making and ranking method to help marketing manager predict their marketing trend.

AMS Subject Classification: 90C70, 47S40, 03F55, 49M37, 90C30.

Key Words and Phrases: Marketing mix, Customer satisfaction, Retailing, Benchmarking, Multicriteria decision-making, Hungarian Algorithm, Fuzzy numbers, Intuitionistic Fuzzy Numbers and Triangular Intuitionistic Fuzzy Numbers.

1 Introduction

The Intuitionistic Fuzzy Assignment problem is a special type of fuzzy linear programming problem and it is a subclass of fuzzy transportation problem [7]. The Intuitionistic Fuzzy Assignment problem can be stated as follows: Let n number ofjobs is performed by number of persons, where the costs depend on the specific assignments. Eachjob must be assigned to one and only one worker and each worker has to perform one and only onejob. The problem is to find such an assignment so that the total cost is optimized. The Intuitionistic fuzzy assignment problem can be applied to nxn Intuitionistic fuzzy cost matrix (C_{ij}), where C_{ij} represents the Intuitionistic fuzzy cost associated with worker $(i = 1, 2, 3 \ldots, n)$ who has performed job $(j = 1, 2, 3, \ldots, n)$. The Intuitionistic fuzzy assignment problem when costs are Triangular fuzzy numbers can also be modelled as $0 - 1$ integer programming problem.
The Intuitionistic fuzzy unbalanced assignment problems can be solved by the method proposed for unbalanced assignment method.The unbalanced assignment problem can be changed to balanced assignment problem and after solving the problem by assignment technique we use the method of Intuitionistic triangular fuzzy number method. In this paper, the procedure is best illustrated with the help of a sample problem.

Data mining can be performed in different kinds of databases and data repositories. The descriptive and productive are the classification of finding pattern through mining data. Through descriptive characterize the general properties of the data. By performing current data to predict some knowledge in predictive method. To find level of abstraction in business world, data mining provide more functionality. Those efficient mining methods address the wholesale business, business trends, business analysis, CRM, ERP, etc [Biggiero, 2003a]. Those functionalities moderately touch the retail business data. In a retail business world, companies/manufacturers want to know about their products sales efficiency and its customer satisfaction. Many companies promoting products to the target different kind of customers. For that many number of products same in nature but from different companies. Sales behaviours of some product are good and some of them are not much up to that level[8]. To analyse the rating and ranking of such products by customer credit ratio the proposed algorithm evaluates loose coupling data mining in a randomized data [1].

2 Preliminaries

In this section some basic definitions and arithmetic operations are reviewed.

2.1 Mathematical Formulation of Assignment problem

The objective is to minimize the total cost of assignment. If job I is assigned to operator 1, the cost is $(C11X_{11})$. Similarly, for job 1, operator 2 the cost is $(C_{12}X_{12})$. The objective function is

$$\text{Minimize } = \sum_{i=1}^{n} \sum_{j=1}^{n} C_{ij} X_{ij}$$

Since one job (i) can be assigned to any one ofthe operators, we have following constraint set:

$$\sum_{i=1}^{n} X_{ij} = 1; \text{ for all } j; \ j = 1, 2, n$$

Similarly for each operator, there may be only one assignment ofjob. For this, the constraint set is:

$$\sum_{i=1}^{n} X_{ij} = 1; \text{ for all } i; \ i = 1, 2, n$$

The non-negativity constraint is:

$$X_{ij} > 0$$

$$\text{Minimize } Z = \sum_{i=1}^{n}\sum_{j=1}^{n} C_{ij}X_{ij}$$

$$\text{Subject to } \sum_{i=1}^{n} X_{ij} = 1; \text{ for all } j; \ j = 1, 2, n$$

$$\sum_{j=1}^{n} X_{ij} = 1; \text{ for all } i; \ i = 1, 2, n$$

$$X_{ij} \geq 0 \text{ for all } i \text{ and all } j.$$

2.2 Unbalanced assignment problem to change into balanced assignment problem

The number of rows is not equal to the number of columns, then the problem is termed as unbalanced assignment problem then this problem changed into balanced assignment problem as follows necessary number of dummy rows/columns are added such that the cost matrix is a square matrix, the values for the entries in the dummy rows / columns are assumed to be zero.

Definition 1 (Fuzzy set)**.** A Fuzzy set $\tilde{A}$ is defined by $\tilde{A} = \{x, \mu_A(x)\}; x \in A, \mu_A(x) \in [0, 1]$. In the pair $(x, \mu_A(x))$, the first element x belong to the classical set A, the second element $\mu_A(x)$, belong to the interval $[0, 1]$ called membership function.

Definition 2 (Intuitionistic Fuzzy Set)**.** An Intuitionstic fuzzy set $\tilde{a}$ assign the each element x of the universe X a membership degree $\mu_{\tilde{a}}(x) \in [0, 1]$ and non membership degree $\nu_{\tilde{a}}(x) \in [0, 1]$ such that $\mu_{\tilde{a}}(x) + \nu_{\tilde{a}}(x) \leq 1$. An IFS $\tilde{a}$ is mathematically represented as $\{< x, \mu_{\tilde{a}}(x), \nu_{\tilde{a}}(x) > x \in X\}$.

Definition 3 (Intuitionistic Triangular Fuzzy Number)**.** A triangular intuitionistic fuzzy number (TIFN) $\tilde{A}^I$ is an
intuitionistic fuzzy set in R with the following membership function $\mu_{\tilde{A}^I}(x)$ and non-membership function $\nu_{\tilde{A}^I}(x)$

$$\mu_{\tilde{A}^I}(x) = \begin{cases} \frac{x-a_1}{a_2-a_1}, & a_1 \leq x \leq a_2 \\ \frac{x-a_3}{a_2-a_3}, & a_2 \leq x \leq a_3 \\ 0, & \text{otherwise} \end{cases} \text{ and } \nu_{\tilde{A}^I} = \begin{cases} \frac{a_2-x}{a_2-a_1{}'}, & a_1{}' \leq x \leq a_2 \\ \frac{x-a_2}{a_3{}'-a_2}, & a_2 \leq x \leq a_3{}' \\ 1, & \text{otherwise} \end{cases}$$

Where $a_1{}' \leq a_1 \leq a_2 \leq a_3 \leq a_3{}'$ and $\mu_{\tilde{A}^I}(x) + \nu_{\tilde{A}^I}(x)\ 1$ or $\mu_{\tilde{A}^I}(x) = \nu_{\tilde{A}^I}(x)$, for all $x \in R$. This TIFN is denoted by $\tilde{A}^I = (a_1, a_2, a_3; a_1^{'}, a_2, a_3{}') = (a_1, a_2, a_3); (a_1^{'}, a_2, a_3{}')$

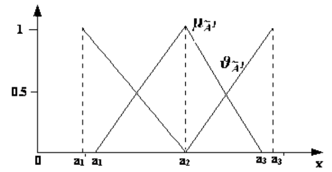

Figure 1: Membership and non-membership functions of TIFN

Definition 4 (Positive triangular intuitionistic fuzzy number). A positive triangular intuitionistic fuzzy number is denoted as $\{(a_1, a_2, a_3); (a_1', a_2, a_3')\}$ where all a_i's and a_i''s > 0 for all $i = 1, 2, 3$.

Definition 5 (Negative triangular intuitionistic fuzzy number). A negative triangular intuitionistic fuzzy number is denoted as $\{(a_1, a_2, a_3); (a_1', a_2, a_3')\}$ where all a_i's and a_i''s < 0 for all $i = 1, 2, 3$.

Definition 6 (Arithmetic operations of triangular intuitionistic fuzzy numbers using function principle). The following are the modified operations that can be performed on triangular intuitionistic fuzzy numbers:

Let $\tilde{A}^I = \left\{(a_1, a_{2,}, a_3)\,; \left(a_1^{'}, a_2, a_3^{'}\right)\right\}$ and $\widetilde{B}^I = \{(b_1, b_2, b_3); (b_1^{'}, b_2, b_3{}')\}$. Then

(i) Addition:
$\tilde{A}^I + \tilde{B}^I = \left\{(a_1 + b_1, a_2 + b_2, a_3 + b_3)\,; \left(a_1^{'} + b_1^{'}, a_2 + b_2, a_3^{'} + b_3^{'}\right)\right\}$.

(ii) Subtraction:
$\tilde{A}^I - \tilde{B}^I = \left\{\left(a_1 - b_3, a_2 - b_2, a_3 - b_1\right); \left(a_1^{'} - b_3^{'}, a_2 - \mathrm{b}_2, a_3^{'} - b_1^{'}\right)\right\}$.

(iii) Multiplication:

$$\begin{aligned}\tilde{A}^I \times \tilde{B}^I = \{&(\min(a_1b_1, a_1b_3, a_3b_1, a_3b_3), a_2b_2, \max(a_1b_1, a_1b_3, a_3b_1, a_3b_3)),\\ &(\min(a_1'b_1', a_1'b_3', a_3'b_1', a_3'b_3'), a_2'b_2', \max(a_1'b_1', a_1'b_3', a_3'b_1', a_3'b_3'))\}\end{aligned}$$

(iv) Division:

$$\begin{aligned}\tilde{A}^I/\tilde{B}^I = \Bigg\{&\left(\min\left(\frac{a_1}{b_1}, \frac{a_1}{b_3}, \frac{a_3}{b_1}, \frac{a_3}{b_3}, \frac{a_2}{b_2}\right), \max\left(\frac{a_1}{b_1}, \frac{a_1}{b_3}, \frac{a_3}{b_1}, \frac{a_3}{b_3}\right)\right),\\ &\left(\min\left(\frac{a_1'}{b_1'}, \frac{a_1'}{b_3'}, \frac{a_3'}{b_1'}, \frac{a_3'}{b_3'}, \frac{a_2'}{b_2'}\right), \max\left(\frac{a_1'}{b_1'}, \frac{a_1'}{b_3'}, \frac{a_3'}{b_1'}, \frac{a_3'}{b_3'}\right)\right)\Bigg\}\end{aligned}$$

Definition 7 (Accuracy Function). Let $\tilde{A}^I = \{a_1, a_2, a_3) : (a_1', a_2, a_3')\}$ be a TIFN then we define $\tilde{A}^I = \dfrac{[(a_1 + 2a_2 + a_3) + (a_1' + 2a_2 + a_3')]}{8}$ an accuracy function of $\tilde{A}^I$, to be defuzzify the given number.

Definition 8 (New operation on intuitionistic triangular fuzzy number (Irene.2014)).
Subtraction: Let $\tilde{A}^I = \{(a_1, a_{2,}, a_3)\,;(a_1', a_2, a_3')\}$ and $\tilde{B}^I = \{(b_1, b_2, b_3); (b_1', b_2, b_3')\}$.
Then $\tilde{A}^I - \tilde{B}^I = \{(a_1 - b_1, a_2 - b_2, a_3 - b_3); (a_1' - b_1', a_2 - b_2, a_3' - b_3')\}$.
The new subtraction operation exists only if the following conditionsare satisfied $D(\tilde{A}^I) \geq D(\tilde{B}^I)$ and $D(\tilde{A}^{I'}) \geq D(\tilde{B}^{I'})$, where $D(\tilde{A}^I) = \frac{a_3 - a_1}{2}$,$D(\tilde{B}^I) = \frac{b_3 - b_1}{2}$, $D(\tilde{A}^{I'}) = \frac{a_3' - a_1'}{2}$ and $D(\tilde{B}^{I'}) = \frac{b_3' - b_1'}{2}$. Here D denotes difference point of a intuitionistic triangular fuzzy number.
Division:
Let $\tilde{A}^I = \{(a_1, a_{2,}, a_3)\,;(a_1', a_2, a_3')\}$ and $\tilde{B}^I = \{(b_1, b_2, b_3); (b_1', b_2, b_3')\}$. Then $\tilde{A}^I \,/\, \tilde{B}^I = \left\{\left(\frac{a_1}{b_1}, \frac{a_2}{b_2}, \frac{a_3}{b_3}\right); \left(\frac{a_1'}{b_1'}, \frac{a_2}{b_2}, \frac{a_3'}{b_3'}\right)\right\}$. The new division operator exists only if the following conditions are satisfied $\left|\frac{D(\tilde{A}^I)}{M(\tilde{A}^I)}\right| \geq \left|\frac{D(\tilde{B}^I)}{M(\tilde{B}^I)}\right|$; $\left|\frac{D(\tilde{A}^{I'})}{M(\tilde{A}^{I'})}\right| \geq \left|\frac{D(\tilde{B}^{I'})}{M(\tilde{B}^{I'})}\right|$ and the negative triangular intuitionistic fuzzy number should be changed into negative multiplication of positive triangular intuitionistic fuzzy number.

3 Product ranking

With increasing globalization, local retailers find themselves having to compete with large foreign players by targeting niche markets [1]. To excel and flaunt as a market leader in an ultramodern era and a globalize world, the organizations must strive to harvest from its marketing strategies, benchmarking and company quality policy.

The Hungarian triangular intuitionistic algorithm has several unique features not found in other solution methods; these are the concepts of outranking and indifference and preference thresholds.

The decision problem faced by management has been translated into our market research problem in the form of questions that define the information that is required to make the decision and how this information obtained. The corresponding research problem is to assess whether the market would accept the consensus rankings derive from benchmarking result from the impact of marketing mix on customer satisfaction using a multi-criteria decision making outranking methodology [Borden, N.H.1964].

4 Research Instrument

A non-comparative Liker scaling technique was used in this survey. The questionnaire is divided into 4 sections: customer information, marketing mix model, customer perception and motivating factor. The demography variables measured at a nominal level in Section 1 include gender, ethnic, marital status, age and how often do the respondents shop at the specific retail store [AmyPoh.AL].

A typical test item in a Likert scale is a statement. The respondent is asked to indicate his or her degree of agreement with the statement or any kind of subjective or objective evaluation of the statement. In Section 2, a six-point scale is used in a forced choice method where the middle option of "Neither agree nor disagree" is not available. The questions comprise four attributes such as product, price, promotions, place/distribution; six questions are allocated for each of the 4Ps.

Section 3 evaluates customer's perception using the same scale as practice in Section 2 whereas Section 4, the last part of the questionnaire measure the factor that motivates respondents the most to patronize the specific retail store using the nominal measurement. Simple random sampling technique is used in the research.

5 Data Analysis and Interpretation

The retail market place promotes continuous improvement to survive in a turbulent atmosphere. For that, benchmarking is the exploration for industry best practices that leads to superior performance (Camp,1989). The benchmarking dimension of the retail stores conceives a set of indicators and for this reason assumes the configuration of a multi-criteria analysis[boone,1992]. The literature on retail stores and marketing mix model has identified four major underlying criteria essential to take place in the market place. They are as follows:

ATT_1 : Product Attribute
ATT_2 : Price Attribute
ATT_3 : Promotions Attribute
ATT_4 : Place/Distribution Attribute

An organization will show better performance on the basis of some indicators and worse performance on the basis of some others: "there is no single performance management enterprise system which is best in class across all areas" (Sharif, 2002).

Computed by averaging the scores assigned to all the organizations on the basis of all the criteria, we could obtain the result of the "best in class" in the organization, with the maximum averaged value. Consider four retail stores:

R_1 : Tesco
R_2 : Mydin
R_3 : Carrefour
R_4 : Giant

The contribution of the multi-criteria outranking methodology to the valuation of the impact of marketing mix on customer satisfaction on four retail stores in terms of benchmarking analysis is significant. The application of outranking approach enables the benchmarking of the impact of marketing mix without the necessity of an aggregate indicator obtained by averaging all scores assigned to the organizations on the basis of the different criteria.

6 Intuitionistic triangular fuzzy assignment -Satisfying Methodology

Triangular intuitionistic fuzzy logic will be introduced here. The input of Intuitionistic triangular fuzzy assignment problem the is represented by a multi-criteria matrix as in Table 1, surrounded by a line containing the weights that the decision making assigns to each criterion.

In the factual situation uncertainty plays a role. It has been presented both in certainty and uncertainty situation though Intuitionistic fuzzy assignment problem and logical conclusion have been derived in the fuzzy logic.

Multicriteria matrix

	ATT1 (Product)	ATT_2 (Price)	ATT_3 (Promotion)
R_1	(3.42,4.42,5.42;2.42,4.42,6.42)	(2.94,3.94,4.94;1.94,3.94,5.94)	(2.97,3.974.97;1.97,3.97,5.47)
R_2	(2.91,3.91,4.91;1.91,3.91,5.91)	(2.73,3.73,4.73;1.73,3.73,5.73)	(2.42,3.424.42;1.42,3.42,5.42)
R_3	(3.10,4.10,5.10;2.10,4.10,6.10)	(2.60,3.60,4.60;1.60,3.60,5.60)	(2.71,3.71,4.71;1.71,3.71,5.71)
R_4	(2.90,3.904.90;1.90,3.90,5.90)	(3.02,4.025.02;2.02,4.02,6.02)	(2.76,3.76,4.76;1.76,3.76,5.76)

The Intuitionistic triangular fuzzy assignment problem can be formulated as following:
Minimize $Z = R(1,3,5;0.5,3,5.5)x_{11}+R(1,2,3;0.5,2,3.5)x_{12}+R(0.5,1,1.5;0,1,2)x_{13}+R(1,2,3;0.5,2,3.5)x_{21}+R(3,5,7;2,5,8)x_{22}+R(0.5,1,1.5;0,1,2)x_{23}+R(1,2,3;0.5,2,3.5)_x24+R(0.5,1,1.5;0,1,2)x_{31}+R(1,2,3;0.5,2,3.5)x_{32}+R(2,4,6;1,4,7)x_{33}+R(1,3,5;0.5,3,5.5)x_{34}+R(2,4,6;1,4,7)X_{35}$

Such that

$x_{11}\ x_{12}\ x_{13}\ x_{14} = 1$, $x_{11}\ x_{21}\ x_{31}\ x_{41} = 1$,
$x_{21}\ x_{22}\ x_{23}\ x_{24} = 1$, $x_{12}\ x_{22}\ x_{32}\ x_{42} = 1$,
$x_{31}\ x_{32}\ x_{33}\ x_{34} = 1$, $x_{13}\ x_{23}\ x_{33}\ x_{43} = 1$,
$x_{41}\ x_{42}\ x_{43}\ x_{44} = 1$, $x_{14}\ x_{24}\ x_{34}\ x_{44} = 1$,
$x_{51}\ x_{52}\ x_{53}\ x_{54} = 1$, $x_{15}\ x_{25}\ x_{35}\ x_{45} = 1$

Equivalent minimization assignment problem for the above maximization problem.

	ATT1 (Product)	ATT_2 (Price)	ATT_3 (Promotion)
R1	$(0,0,0;-0.4,0,-0.4)$	(0.48,0.48,0.48;-3.52,0.48,4.48)	(0.45,0.45,0.45;-3.44,0.45,4.45)
R_2	$(0.51,\ 0.51,\ 0.51; -3.31, 0.51, 4.51)$	(0.69, 0.69, 0.69;-3.31, 0.694.69)	$(1,1,1;-3,1,5)$
R_3	$(0.32,\ 0.32,\ 0.32; -3.680.32, 4.32)$	(0.82, 0.82, 0.82;-3.18, 0.82,4.82)	(0.71,0.71,0.71;-3.29,0.71,4.71)
R_4	(0.52, 0.52, 0.52;-3.48,0.52,4.52)	(0.4,0.4,0.4;-3.6,0.4,4.4)	(0.66,0.66,0.66;-3.33,0.66,4.66)

After using Hungarian process we get result table has been given

	ATT1 (Product)	ATT_2 (Price)	*ATT3* (Promotion)
R_1	$[(0,0,0;-16,0,16)]$	(0.36,0.36,0.36;-16.36,0.36, 15.64)	(0.19,0.19,0.19;-16.71,0.19,15.18)
R_2	$(0,0,0;-16,0,16)$	$[(0,0,0;-32,0,32)]$	(0.10,0.10,0.10; - $65.28, 0.10, 64.87)$
R_3	$(0,0,0;-16,0,16)$	(0.32,0.320.32;-32.44.0.32,32.66)	$[(0,0,0;-64.77,0,64.77)]$
R_4	$(0,0,0;-16,0,16)$	$(0,0,0;-16,0,16)$	(0,0,0,;-15.99,0, 15.99)

7 Conclusion

As can be seen, the marketing manager should have rough outline to assign Product to Rl,Price to R2,promotion to R3 and Place or Distribution to R4. However, at this stage, there will likely be many potential directions for the managers to pursue. The manager must prioritize all marketing activities and develop specific goals and objectives for the marketing plan.

It the effort of avoiding the shortcomings of the traditional methods based on the average aggregate monocriterion, outranking methods make it possible to deal with multicriteria benchmarking. They are a complete alternative to the traditional approach proviso applied to the measurement oflearning capability. The retail stores management uses the information so obtained to interpret the needs of individuals in the marketplace, and to create strategies, schemes and marketing plans.

The more the satisfying solutions will be when the lower the threshold assigned to the concordance test computing the lower the aspiration levels as a result.

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