A Fuzzy Preference Relations to Service Innovation Project Selection

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Abstract

In order to reduce the bias of linguistic recognitions among the group decision makings, this study develops "fuzzy multiple preference model" with two stages to better determining the suitable service innovation. A real numerical application in the chain wholesale has also been demonstrated.

Keywords: Preferences Relations, Service Innovation, Fuzzy Sets

1. Introduction

People have many tendencies in multiple criteria decision making of preference formats: preference orderings, utility values, multiplicative preference relation, linguistic terms, and pairwise comparison (Kahraman et al., 2003). However, the decision makers may have vague knowledge about the preference degree of one alternative over another, and cannot estimate their preferences with exact numerical values. Furthermore, it is too complex or too ill-defined to be amenable for description in conventional quantitative expressions.

It is more suitable to provide their preferences by means of fuzzy linguistic variables rather than numerical ones (Herrera et al., 2001; Xu, 2003). Though the given linguistic data can simplify the computational technique and the aggregation of the linguistic preference information, it is unable to really understand the decision makers' subjective cognitions experienced by the concept of the interval purpose. Herrera et al. (2002) note the decision makers may have diverse cultural, educational backgrounds and value systems, their preference would be expressed in different ways. It is valuable to integrate the cognitive difference of preference attitudes among the decision makers for improving the decision quality.

In addition, in order to reduce their cognitive burdens in the assessments process, linguistic terms can be used to express decision makings' subjective judgments. It can facilitate the human rating feelings through linguistic terms which are better modeled by fuzzy numbers, such as triangular shape. In the meanwhile, the use of preference information in different formats has attracted many researchers' interestings (Chiclana et al., 1998; Herrera et al., 2001; Herrera et al., 2002)

2. The integrated model of fuzzy multi-linguistic preference

We provide an integrated approach of multi-linguistic preference which allows us to solve the linguistic diversity of decision process. The following two steps for developing the decision process are proposed. The first step focuses on establishing a collective linguistic preference profile and combines the individual fuzzy linguistic information. The first step is carried out in two phase: (1) Making the information uniform; (2) Computing the collective performance value. In the second step, a fuzzy preference relation is computed from the collective performance values and a choice degree has been used to reach a style set of service innovations in retail business.

2.1. Making the preference information uniform

Step 1: Definition of basic linguistic terms

Firstly, We have to decide how to choose basic linguistic term set S_T. Miller (1956) thinks normally a person is able to discriminate 11 or 15 terms. In order to contain most the linguistic difference from decision makers, we define a basic linguistic term set with 15 terms and the following semantics.

Step 2: Definition of fuzzy linguistic transformation function

Let $A = \{l_1,\ l_2,...,\ l_p\}$ and $S_T = \{c_1,\ c_2,...,\ c_g\}$ be two linguistic term sets, such that, $g \geq p$. Then, a multi-linguistic preference transformation function τ_{AS_T} is defined as:

$$\tau_{AS_T}: A \rightarrow F(S_T),$$
$$\tau_{AS_T}(l_i) = \{(c_k, \alpha_k^i) | k \in (1, 2, ..., g)\}, \quad \forall l_i \in A.$$
where, $\alpha_k^i = \max_y \min\{u_{l_i}(y), u_{c_k}(y)\}$.

$F(S_T)$ is the set of fuzzy sets defined in S_T, and $u_{l_i}(y)$ and $u_{c_k}(y)$ are the membership degree of the fuzzy sets associated to the terms l_i and c_k, respectively. Therefore, the result of τ_{AS_T} for any linguistic value of A is a fuzzy set defined in the basic linguistic term set, S_T (see Fig. 1).

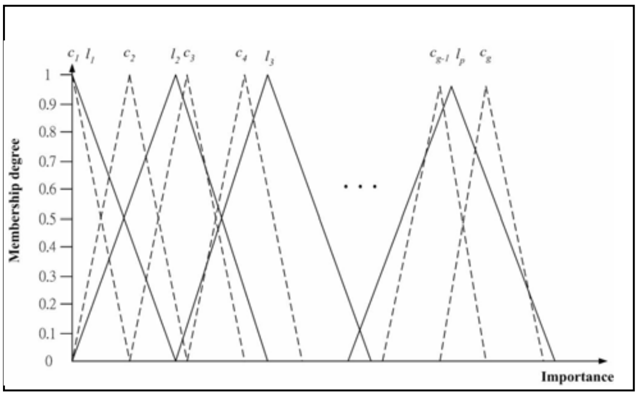

Fig. 1: Fuzzy linguistic transformation function.

Step 3: Integrated multi-linguistic preference dimensions

We represent linguistic performance value p^{ij} as a fuzzy set defined on $S_T = \{c_1, ..., c_g\}$ characterized by the equation (1):

$$\tau_{A_j S_T}(p^{ij}) = \{(c_1, \alpha_1^{ij}), (c_2, \alpha_2^{ij}), ..., (c_g, \alpha_g^{ij})\} \quad (1)$$

Thus, the performance profile of each decision maker p_j is represented as a set of fuzzy sets on S_T as equation (2):

$$\{\tau_{A_j S_T}(p^{1j}), \tau_{A_j S_T}(p^{2j}), ..., \tau_{A_j S_T}(p^{nj})\} \quad (2)$$

We denote $\tau_{A_j S_T}(p^{ij})$ as r^{ij}, and represent each fuzzy set of performance, r^{ij}, by means of its respective membership degree as equation (3):

$$r^{ij} = (\alpha_1^{ij}, \alpha_2^{ij}, ..., \alpha_g^{ij}) \quad (3)$$

2.2. Computing collective performance values

The collective performance value of a service innovation style x_i according to all the source evaluations $\{r^{ij}, \forall j\}$ is obtained by means of the aggregation of these fuzzy sets. This collective performance value, denoted r^i, is a new fuzzy set defined on S_T as equation (4):

$$r^i = (\alpha_1^i, ..., \alpha_k^i, ..., \alpha_g^i) \quad (4)$$

Equation (4) is characterized by the following membership function:

$$\alpha_k^i = F(\alpha_k^{i1}, ..., \alpha_k^{im})$$

where, F is an "aggregation operator".

Therefore, the result of this step in our decision process is a set of collective evaluations, which provides the collective performance value of each service innovation style according to all the decision makers evaluations, i.e., $\{r^1, r^2, ..., r^n\}$.

2.3. The second step: choosing the service innovation styles

2.3.1 Computing a fuzzy preference relation

Let $x_i, x_j \in X (i \neq j)$ be two alternatives with their respective collective performance fuzzy sets $r^i, r^j \in F(S_T)$; then the degree of possibility of dominance of x_i over x_j, b_{ij}, is obtained according to the equation (5) (Dubois & Prade, 1983):

$$b_{ij} = \max_l \min_{h \leq l}\{\alpha_l^i, \alpha_h^j\}, \quad c_l, c_h \in S_T \quad (5)$$

Applying equation (5) over all of possible pairs of the service innovation styles ($i \neq j$), we obtain a fuzzy preference relation $B = [b_{ij}]$.

2.3.2 The non-dominance of degree choosing service innovation styles

Let $B = [b_{ij}]$ be a fuzzy preference relation defined over a set of alternatives X. For the alternative x_i, its non-dominance degree, NDD_i, is obtained as equation (6)(Orlovski, 1978):

$$NDD_i = \min_{x_j}\{1 - b_{ji}^s, j \neq i\} \quad (6)$$

where, $b_{ji}^s = \max\{b_{ji} - b_{ij}, 0\}$ represents the degree to which x_i is strictly dominated by x_j. The alternative with the maximum NDD_i obtains the highest performance in service innovations.

3. Empirical study

3.1. The collection and identification of linguistic data

We investigate a certain chain wholesale in Taiwan and analyzed the service innovation directions of development in the future, including four kinds of service innovations: Multi-unit organization (x_1), New combination of service (x_2), Technological innovations (x_3), Design changes (x_4). Besides, the chain wholesale has a group of four consultancy departments to evaluate the performance of the service innovations, including risk analysis department (p_1), marketing analysis department (p_2), food and merchandise department (p_3), information administrative department (p_4), respectively. The four consultancy departments provide the assessments and the planning for the basis of the service innovations of development in the chain wholesale. Each expert has different linguistic preferences and attitudes for each department, and thus each expert is an information source. These experts use, to provide their preference over the service innovation sets, different linguistic term sets, specifically.

Each linguistic interval preferred by experts is investigated, including left point, middle point and right point. Finally, according to the collection data from interval values, we establish fuzzy linguistic membership function of each expert in separate analysis department. After an in-depth interview, each expert provides the performance values according to his cognitive linguistic terms. The performance of service innovation styles evaluated in different marketing situations includes: (1) Existed commodities and new markets; (2) New commodities and existed markets; (3) New commodities and new markets. And there are three kinds of service supporting; that is (1) Service procedure supporting; (2) Personnel's technological supporting; (3) Entity's facility supporting.

3.2. Choosing the best service innovation style

3.2.1 Computing a fuzzy preference relation

According to the collective performance values, we obtain the dominance degree among the service innovation styles. That is to say, we get the collective preference relation $B=[b_{ij}]$ for each expert's perception with service innovation styles. Therefore, from the above collective evaluations, we find the following fuzzy preference relation B:

$$B = \begin{matrix} \\ r^1 \\ r^2 \\ r^3 \\ r^4 \end{matrix} \begin{pmatrix} r^1 & r^2 & r^3 & r^4 \\ - & 0.12 & 0.45 & 0 \\ 0.45 & - & 0.67 & 0.27 \\ 0.45 & 0.25 & - & 0.12 \\ 0.27 & 0.27 & 0.27 & - \end{pmatrix}$$

3.2.2 Applying the non-dominance choice degree to evaluate service innovations

According to the result of fuzzy preference relation B, we compute the non-dominance choice degree by equation (6) to choose the best service innovation style. Firstly, the strict preference relation B^S is computed:

$$\begin{matrix} & & r^1 & r^2 & r^3 & r^4 \end{matrix}$$
$$B^S = \begin{matrix} r^1 \\ r^2 \\ r^3 \\ r^4 \end{matrix} \begin{pmatrix} - & 0 & 0 & 0 \\ 0.33 & - & 0.52 & 0 \\ 0 & 0 & - & 0 \\ 0.27 & 0 & 0.15 & - \end{pmatrix}$$

Then, we compute the non-dominance choice degree of each service innovation:

$$\{NDD_1 = 0.67,\ NDD_2 = 1,\ NDD_3 = 0.48,\ NDD_4 = 1\}$$

And finally, we can obtain the non-dominance degree value in different service innovation styles of "new commodities, new markets" vs. "service procedure supporting". The higher the non-dominance degree value, the more performance can be operated in the retailing business environments. Similar evaluated results both "new commodities, new markets" vs. "personnel's technological supporting" and "new commodities, new markets" vs. "entity's facility supporting" are enumerated for the other levels of the decision phase.

Table 1 lists the non-dominance degree values showing the interrelationship among the different market situations and service supportings. The non-dominance degree values of the service innovations (x_1, x_2, x_3, x_4) can be calculated, giving values of (0.67, 1, 0.48, 1) for service procedure supporting, (0.67, 1, 0.48, 1) for personnel's technological supporting, and (0.45, 0.77, 1, 1) for entity's facility supporting.

These alternatives have been proposed by the decision-makers. Each service innovation style has different benefits. For example, Service procedure supporting features "new combination of service" and "Design changes" while providing adequate infrastructure, bundle commodities and additional service supplies.

Table 1 The non-dominance degree values in different market situations and service supportings

Marketing Situations	Service Innova-tions	Supportings		
		Service procedure supporting	Personnel's technological supporting	Entity's facility supporting
New commodities and new markets	x_1	0.67	0.39	0.45
	x_2	1	0.83	0.77
	x_3	0.48	0.54	1
	x_4	1	0.83	1

4. Concluding remarks

In this study, we propose the concept of the integrated model of fuzzy multi-linguistic preference derived from the inconsistent group decision makings which express their opinions in different linguistic specialties they prefer. Most group decision makings often assume that the linguistic data has already been known and seen as ongoing programmed of goal evaluations. In fact, decision makers own their inherently diverse cultures and value systems to affect subjective linguistic preferences. Besides, the traditional decision structures also suppose the collected data as crisp numbers that ignore the inherent vagueness and uncertainty belonged to decision makers' behaviors. This would make the analytic results in the whole process conflict and inconsistently.

In this study we combine the fuzzy sets theory with the multi-linguistic preference analysis structure for the purpose of reducing the inconsistent operations between researchers and practitioners. The most significant contribution of this study is the setting-up of the integrating different linguistic preferences through the framework of the basic linguistic terms and the linguistic transformation functions, which offer the common platform to assess comparable analysis among all diverse linguistics. Furthermore, the fuzzy preference relations and non-dominance values in the study provide the net effects to exclude the interference with others' service innovations, which have been neglected by the traditional service innovation researches. As a matter of fact, both solving the constraint of diverse linguistic preferences to a broader scope and covering fuzzy linguistic concepts to constitute a holistic approach with the suitable service innovation styles, have gradually become a major task for retail business marketing. In this way, the integrated model of fuzzy multi-linguistic preference has not only solved the neglecting issues for the difference of linguistic formats and diverse data, but also overcome the conflicts of being unable to combine different fuzzy linguistic intervals.

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