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Using Stochastic Multi Criteria Decision Making Technology to Evaluate Service Quality of Restaurant

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Abstract

Catering industry is one of service industry which can earn more stable operating profit and can generate a huge amount of job opportunity. However, catering industry is a high competitive industry and restaurants in catering industry usually face a lot of competitors. Service quality of restaurant is the competitive ability index in restaurant. So, it is an important issue to evaluate service quality of restaurant. The goal of this study is to develop a framework to evaluate service quality of restaurant for providing useful tool to restaurant. Based on proposed method, each restaurant can understand its service quality according to a huge amount of consumers' opinion and understand its competitive position. In order to let reader, realize our method, a numerical example will be implemented to explain proposed method. Finally, some conclusion and future research will be discussed as ending.

JEL classification numbers: M10, C44, O14
Keywords: Restaurant Management, Linguistic Variable, Stochastic Multi Criteria Decision Making.

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1. Introduction

Service industry is an important industry. This industry can generate a lot of gross domestic product (GDP) and increases a huge amount of job for country (Xiaojuan and Hui, 2004). There are various kind of sub industries in service industry. Catering industry is one of service industry which can generate more stable operating profit because the product of this industry is people's livelihood necessities. Especially, some high-quality restaurants can generate a lot of margin profit and will attract some tourism from other country for entering this restaurant. However, catering industry is a high competitive industry. Restaurants in catering industry usually face a lot of competitors. Service qualities of restaurants are not easy to maintain because there are a lot of tacit knowledge in serving customer and cooking food. Tacit knowledge is not easy to be described by standard operation process (SOP) (McKinlay, 2002; Lee and Kim, 2017). For maintaining the competitive ability of restaurant, evaluation of restaurant service quality is an important activity for restaurant. There are some literatures which is discussed about service quality is as follows.

Heung et al. (2000) used SERVQUAL to investigate service quality of Hong Kong airport restaurant. Brady and Cronin (2001) built hierarchical criteria to analyze the service quality according to consumers' opinion. Their arranged service quality criteria includes reliable, responsive, and empathetic etc. They used those criteria to analyze each kind of service industries. Sulek and Hensley (2004) analyzed quality of restaurants from 239 consumers' opinion in full-service restaurant in the southeastern United States. According to experiment result, customer satisfaction, food quality, restaurant's atmosphere and fairness are the most important factors to measure service quality of restaurants. Benitez et al. (2007) applied fuzzy number and TOPSIS to evaluate service quality of hotel industry. Xue et al. (2008) collected some literatures and built some criteria for evaluating fast food restaurant (FFR) service quality. They surveyed fast food restaurant consumers' opinion to analyze the service quality of 4 FFR in China and 8 FFRs in US by using TOPSIS method. This work also pointed out the core competence of fast food restaurant for providing some suggestion to enterprise. Lee et al. (2012) analyzed the relationship between customer satisfaction and service quality in restaurant industry. This research showed that it generated significant differences in perceptions of service quality between male and female older customers. Besides, there were some differences in perceptions of service quality between older and younger customers. Gharakhani et al. (2012) applied data envelopment analysis (DEA) method to analyze the service efficiency of fifteen restaurants in Iran. Research result shows that Nemoone restaurant and Noor restaurant is the most efficient restaurants in Iran. Yildiz and Yildiz (2015) used analytical hierarchy process (AHP) method to determine dimensions of service quality and weight of those dimension in restaurants. After that, TOPSIS are used to analyze and evaluate the integrated service quality performance of three Trabzon restaurants. Pai et al. (2016) used DINESERV to design questionnaire and surveyed consumers' opinion in chain restaurant industry.

And then, importance-performance analysis (IPA) and Kano model were used to analyze service quality of restaurants. Yang et al. (2017) used decision-making trial and evaluation laboratory (DEMATEL), dynamics analytic network process (DANP) and VIKOR to analyze the relation of each criterion of service quality. The goal of this work is to develop a framework to evaluate restaurant service quality for providing useful tool to restaurant.

The content of this study is as follows. First, some notation about 2-tuple linguistic variable will be described. And then, proposed method will be discussed in next section. For reader understand proposed method, a numerical example will be explained in section 4. Some conclusion and future research will be discussed as ending.

2. Primary

Definition 1. Let V=$\{V_0, V_1, V_2, \dots, V_t\}$ be totally ordered and finite linguistic term set. $\tilde{S}_a = (\alpha s_a, (1-\alpha)s_{a+1})$ represents the interval linguistic variable where s_a and s_{a+1} means the central value of a-th and a+1-th linguistic term in S and α means the numerical value and it means the ratio of central value of a-th linguistic term s_a and the central value of a+1-th linguistic term s_{a+1}(Martinez and Herrera, 2012).

Definition 2. Let ε() be the linguistic transfer function. ε() can translate linguistic variable into crisp value Λ according to the following equation (Liu et al., 2015)

$$\varepsilon(s_a)=a/(t-1) \tag{1}$$

where t is the scale of linguistic term and a=1,2,…,t-1.

Definition 3. Let Ω() be the symbolic translation function, Ω() can translate crisp value Λ into the interval linguistic variable according to the following equation (Li and Yuan, 2017)

$$\Omega(\Lambda)= (\alpha s_a, (1-\alpha)s_{a+1}) \tag{2}$$

Where $\varepsilon(s_a) \le \Lambda \le \varepsilon(s_{a+1})$ and $\alpha=(t-1)*(\varepsilon(s_a)-\Lambda)$.

Definition 4. Let $\Omega^{-1}()$ be the symbolic inverse translation function, $\Omega^{-1}()$ can translate the interval linguistic variable into crisp value Λ according to the following equation (Li and Yuan, 2017).

$$\Omega^{-1}(\tilde{S}_a)= \Omega^{-1}((\alpha s_a, (1-\alpha)s_{a+1}))=\alpha\varepsilon(s_a)+(1-\alpha)\,\varepsilon(s_{a+1}) \tag{3}$$

3. Stochastic multi criteria decision making method

Generally speaking, the notation of stochastic multi criteria decision making method is as follows.

(1) A set of alternative $A=\{A_1, A_2, \dots, A_m\}$ where m represents the volume of alternatives.
(2) A set of criteria $C=\{c_1, c_2, \dots, c_n\}$ where n represents the volume of criteria.
(3) A weight set of criteria $W=\{w_1, w_2, \dots, w_n\}$.
(4) A set of Expert $E=\{E_1, E_2, \dots, E_\varphi\}$ Where φ represents the volume of Experts.
(5) Decision matrix $D=[d_{x,y}]_{m*n}$ where $d_{x,y}$ represents the performance of alternative x respect to criteria y.
(6) Distribution decision matrix $P=[p_{x,y,z}]_{m*n*o}$. $p_{x,y,z}$ represents the occurrence probability of linguist variable z which is selected by some experts as the performance of alternative x respect to criterion y.

The execution process of multi criteria decision making method can be executed by following steps.

Step 1. Organization should decide evaluation target and select some expert to execute decision making.
Step 2. Experts decide some criteria to evaluate the performance of each alternative.
Step 3. Expert uses interval linguistic variable to analyze performance of each alternative respect to each criterion. $d_{x,y}^z$ means the opinion of evaluator z about the performance of alternative x respect to criterion y.
Step 4. The importance of each criterion can be calculated by following equation

$$w_y = \frac{\left(\frac{\sum_{i=1}^{m}\sum_{j=1}^{k}\left(\Omega^{-1}\left(d_{i,y}^k\right)-\Omega^{-1}\left(d_{i,y}\right)\right)^2}{m*k}\right)^{0.5}}{\sum_{l=1}^{n}\left(\frac{\sum_{i=1}^{m}\sum_{j=1}^{k}\left(\Omega^{-1}\left(d_{i,l}^k\right)-\Omega^{-1}\left(d_{i,l}\right)\right)^2}{m*k}\right)^{0.5}} \tag{4}$$

where $d_{x,y} = \Omega\left(\frac{\sum_{i=1}^{k}\Omega^{-1}\left(d_{x,y}^k\right)}{k}\right)$. $d_{x,y}$ means the integrated opinion about the performance of alternative x respect to criterion y.

Step 5. Calculate the performance distribution of each alternative respect to each criterion. The occurrence probability of linguist variable z which is selected by experts to represent performance of alternative x respect to criteria y ($p_{x,y,z}$) can be calculated by following equation

$$p_{x,y,z}=\frac{\sum_{i=1}^{k} Ж_z(d_{x,y}^{k})}{k} \quad (5)$$

where $Ж_z(g)=\begin{cases}1, \text{if } \Omega^{-1}(l_z,\delta_z)=\Omega^{-1}(g)\\ 0, \text{if } \Omega^{-1}(l_z,\delta_z)\neq\Omega^{-1}(g)\end{cases}$

Step 6. Calculate positive ideal solution (PIS) $p_y^{*}=\{p_y^{z*}\}$ z=1,2,…,a. It can be calculated by following equation

$$p_y^{*}=\begin{cases}p_{y,1=0}\\ \quad\quad\ldots\\ p_{y,k-1=0}\\ p_{y,k}=1-\sum_{i=a}^{k+1} p_{x,y,i}\\ p_{y,k+1=\max_q\{p_{q,y,k+1}\}}\\ \quad\quad\ldots\\ p_{y,a}=\max_q\{p_{q,y,a}\}\end{cases} \quad (6)$$

Step 7. Calculate negative ideal solution (NIS) $p_y^{-}=\{p_y^{z-}\}$ z=1,2,…,a. It can be calculated by following equation

$$p_y^{-}=\begin{cases}p_{y,1}^{-}=\max_q\{p_{q,y,1}\}\\ \quad\quad\ldots\\ p_{y,k-1}^{-}=\max_q\{p_{q,y,k-1}\}\\ p_{y,k}^{-}=1-\sum_{i=1}^{k-1} p_{x,y,k}^{-}\\ p_{y,k+1}^{-}=0\\ \quad\quad\ldots\\ p_{y,k+1a}^{-}=0\end{cases} \quad (7)$$

Step 8. Calculate the distance between PIS and performance distribution of alternative x respect to criteria y. It can be calculated by following equation

$$d_{x,y}^{+}=d(p_y^{+},p_{x,y})=\left(0.5*[p_y^{+}-p_{x,y}]B[p_y^{+}-p_{x,y}]\right)^{0.5} \quad (8)$$

Step 9. Calculate the distance between NIS and performance distribution of alternative x respect to criteria y. It can be calculated by following equation

$$d_{x,y}^{-}=d(p_y^{-},p_{x,y})=\left(0.5*[p_y^{-}-p_{x,y}]B[p_y^{-}-p_{x,y}]\right)^{0.5} \quad (9)$$

where $p_y^{+}-p_{x,y}$ =(($p_{y,1}^{+}-p_{x,y,1}$), ($p_{y,2}^{+}-p_{x,y,2}$),…, ($p_{y,a}^{+}-p_{x,y,a}$)) , $p_y^{-}-$

$p_{x,y}$ =(($p_{y,1}^{-} - p_{x,y,1}$), ($p_{y,2}^{-} - p_{x,y,2}$),..., ($p_{y,a}^{-} - p_{x,y,a}$)) and B= $[b_{i,j}]_{a*a}$. The equation of $b_{i,j}$ is as follows

$$b_{i,j}=a^2-(i-j)^2 \tag{10}$$

Step 9. Integrated distance between PIS and alternative x (d_x^+) will be calculated according to the following equation.

$$d_x^+=\left(\sum_{j=1}^{n}\left(w_j * d_{x,j}^+\right)^2\right)^{0.5} \tag{11}$$

Step 10. Integrated distance between NIS and alternative x (d_x^-) will be calculated according to the following equation.

$$d_x^-=\left(\sum_{j=1}^{n}\left(w_j * d_{x,j}^-\right)^2\right)^{0.5} \tag{12}$$

Step 11. Relative distance of alternative x will be calculated by following equation

$$\Lambda_x = d_x^-/(d_x^+ + d_x^-) \tag{13}$$

The larger Λ_x , the better alternative x.

4. Numerical example

An catering enterprise wants to evaluate service quality of its restaurants. On this way, four restaurants A_1, A_2, A_3, and A_4 has been ready to be evaluated. The service quality criteria includes food quality (C_1), atmosphere (C_2), dining environment (C_3), server attitude (C_4), service speed and immediateness (C_5) are criteria which are used to evaluate service quality of each restaurant. The evaluation process is as follows.

Step 1. Catering enterprise designs the questionnaire and collect twenty consumers' opinion about service quality of each restaurant. Nine scale of 2-tuple linguistic variable (Refter to Table 1) are employed to evaluate the service quality of each restaurant. The enterprise selects twenty consumers to evaluate service quality of each restaurant and the evaluation result can refer to Table 2.

Table 1: Nine scale of 2-tuple linguistic variable

	Notation	**Content**
Linguistic Variable	S_0^9	(Extreme Poor, EP)
	S_1^9	(Very Poor, VP)
	S_2^9	(Poor, P)
	S_3^9	(Little Poor, LP)
	S_4^9	(Fair, F)
	S_5^9	(Little Good, LG)
	S_6^9	(Good, G)
	S_7^9	(Very Good, VG)
	S_8^9	(Extreme Good, EG)

Table 2: Consumer Opinion of each restaurant

		A_1	A_2	A_3	A_4			A_1	A_2	A_3	A_4
C_1	E_1	VG	G	LP	G	C_2	E_1	P	LP	VG	LP
	E_2	F	VP	LG	F		E_2	VP	F	LP	EG
	E_3	LG	LG	F	P		E_3	LP	LP	LP	G
	E_4	F	P	G	LG		E_4	VP	G	G	LG
	E_5	G	LP	LP	LG		E_5	F	F	P	F
	E_6	VP	G	P	LG		E_6	LG	LG	F	LP
	E_7	F	VP	G	F		E_7	G	LP	LP	G
	E_8	P	EP	LG	G		E_8	LP	LP	P	EP
	E_9	P	LP	P	VP		E_9	G	LP	P	P
	E_{10}	F	P	G	P		E_{10}	LP	VP	LG	F
	E_{11}	EG	LP	LP	P		E_{11}	VG	LP	LG	LG
	E_{12}	F	LP	G	VG		E_{12}	VG	LP	G	LG
	E_{13}	EG	LG	LG	LG		E_{13}	LG	LP	LG	VG
	E_{14}	F	G	G	LP		E_{14}	P	LG	LG	LG
	E_{15}	EP	LP	P	LG		E_{15}	EG	VG	LP	F
	E_{16}	F	G	LP	P		E_{16}	EG	P	LG	F
	E_{17}	LP	G	EP	F		E_{17}	VF	VP	P	VP
	E_{18}	G	LP	EP	VG		E_{18}	F	F	G	LP
	E_{19}	P	P	EG	G		E_{19}	VG	LP	F	LG
	E_{20}	VG	LP	EG	P		E_{20}	LP	P	LG	VG
C_3	E_1	F	LP	P	LP	C_4	E_1	VP	P	G	EP
	E_2	LP	G	G	F		E_2	F	P	P	F
	E_3	F	G	F	VG		E_3	G	P	EG	LG
	E_4	G	F	F	F		E_4	LP	F	F	LP
	E_5	F	LG	LG	LP		E_5	G	VG	LP	P
	E_6	LG	LP	G	LP		E_6	LG	VP	LG	LG
	E_7	G	P	LP	LP		E_7	LP	P	G	LP
	E_8	F	G	LP	VG		E_8	VP	P	F	P
	E_9	F	VG	LG	LP		E_9	LG	F	LG	EP
	E_{10}	F	F	LG	EP		E_{10}	F	EP	VP	P
	E_{11}	P	LP	P	G		E_{11}	LP	LP	P	EP
	E_{12}	G	VP	P	F		E_{12}	LP	VG	VP	VP
	E_{13}	LP	F	P	EP		E_{13}	EG	EG	LG	P
	E_{14}	G	G	VG	F		E_{14}	EP	G	VG	VG
	E_{15}	VP	F	LP	G		E_{15}	F	LP	G	F
	E_{16}	G	G	F	F		E_{16}	F	EP	P	P
	E_{17}	LG	P	LP	P		E_{17}	LP	EG	P	VP
	E_{18}	F	F	LP	F		E_{18}	LP	LP	LP	F
	E_{19}	F	P	G	LP		E_{19}	F	P	LG	LP

	E_{20}	G	LP	LP	P		E_{20}	VP	LP	F	F
	E_1	G	F	F	F						
	E_2	VP	VG	P	LP						
	E_3	LG	VP	F	F						
	E_4	P	LP	F	LG						
	E_5	G	VP	P	F						
	E_6	G	VG	P	P						
	E_7	G	G	LG	F						
	E_8	VG	LG	G	VP						
	E_9	F	VG	P	F						
	E_{10}	LP	G	G	P						
C_5	E_{11}	P	F	G	LG						
	E_{12}	EP	F	LP	LG						
	E_{13}	VP	G	G	P						
	E_{14}	F	VP	P	P						
	E_{15}	G	VG	P	P						
	E_{16}	LG	G	VP	LG						
	E_{17}	EG	VG	VP	VG						
	E_{18}	P	VP	P	G						
	E_{19}	EG	LG	G	F						
	E_{20}	P	LG	F	P						

Step 2. Integrated opinion of each customer , standard deviation and weight of each criterion will be calculated by equation 4 (Refer to Table 3).

Table 3: standard deviation and weight of each criterion

	$\mathbf{C_1}$	$\mathbf{C_2}$	$\mathbf{C_3}$	$\mathbf{C_4}$	$\mathbf{C_5}$
Standard deviation	0.4555	0.5408	0.4273	0.4761	0.4985
weight	0.1899	0.2255	0.1782	0.1985	0.2079

Step 3. The service quality distribution of each restaurant can be arranged by equation 5.

Step4.Positive ideal solution and negative ideal solution can be calculated by equation 6 and equation 7.

Step 5. Distance between PIS and each restaurant can be calculated by equation 8.

Step 6. Distance between NIS and each restaurant can be calculated by equation 9.

Step 7. Integrated distance between PIS and restaurant x (d_x^+) will be calculated by equation 11 (Refer to Table 4).

Step 8. Integrated distance between NIS and restaurant x (d_x^-) will be calculated by equation 12 (Refer to Table 4).

Step 9. Relative distance of each restaurant will be calculated by equation 13 (Refer to Table 4). So, service quality rank of each restaurant is A_2, A_3, A_4 and A_1

Table 4: Integrated distance, relative distance and rank of each restaurant

	$\mathbf{A_1}$	$\mathbf{A_2}$	$\mathbf{A_3}$	$\mathbf{A_4}$
Integrated distance between PIS and each restaurant	0.4332	0.4882	0.4687	0.5045
Integrated distance between NIS and each restaurant	0.3698	0.5359	0.4966	0.4716
Relative distance of each restaurant	0.4605	0.5233	0.5145	0.4831
Rank	**4**	**1**	**2**	**3**

5. Conclusion and Future Research

Restaurant service quality evaluation is an important research topic because enterprise should manage restaurant and evaluate employees' performance according to service quality of restaurant. In past research, each kind of technology are used to analyze service quality of restaurant. However, service quality of restaurant is uncertainty and will be influenced by employees' performance in the special service condition. So, it needs a method to collect a huge amount of consumers' opinion for evaluating service quality of each restaurant objectively. This research use stochastics multi criteria method to evaluate service quality of each restaurant. Based on this method, catering enterprise can understand performance of its own restaurant more objectively.

In the future, scholar can try to integrate proposed method with other kind of MCDM technology such as DEMATEL, fuzzy cognitive map or Kano model to acquire more information for enterprise. Scholar also can develop decision support system based on proposed method for enterprise to use this method because execution process of our method is a little complex when evaluators who are invited to evaluate service quality of restaurant are huge.

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