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Fuzzy application in service quality analysis: An empirical study

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ABSTRACT

Service activities have become the fundamental and dominant factors of the economic system over the past three decades and the significance and influence of service quality have been recognized through the great effect on customer satisfaction and customer loyalty. It should be noted that the assessment results obtained from multiple attributes decision-making problems of diverse intensity, such as service quality evaluation, may be misleading if the fuzziness of subjective human judgment is not taken into account. This paper develops an analysis architecture, which consists of fuzzy measurement of P–I gap, modified P–I analysis for attributes and ranking order determination for subjects, to deal with service quality measurement more effectively. The fuzzy measurement of P–I gap takes advantage of including the vagueness of evaluators' judgment. By using the results of modified P–I analysis, effective ways for improving service quality perceptions can be focused on the attributes of high importance yet poor quality; meanwhile, resources or efforts attached to the attributes of low importance and good quality can be shifted to those of high importance yet poor quality. According to the ranking order of subjects, managers could devote more efforts to assist the subjects with inferior rankings to improve the service activities. The proposed analysis architecture can be used to investigate service quality effectively and track the trends periodically. An empirical study is conducted by using the proposed approach.

1. Introduction

Early research efforts on quality research in the 1920s focused on measuring the quality in manufacturing and assembling industries. As service activities have become the fundamental and dominant factors of the economic system over the past three decades, studies in service quality started to increase. Relevant studies indicated that service quality is a key factor for survival and development in today's keen competition, the significance and attention in service quality has grown noticeably (Ghobadian, Speller, & Jones, 1994). Researchers (e.g., Buttle, 1996; Caruana, 2002; McDougall & Levesque, 2000; Teas, 1994) argued that good service quality is antecedent to customer satisfaction and then customer satisfaction is antecedent to customer loyalty. Su (2004) pointed out that service quality is a critical factor for any business to become successful. Regarding the difficulty in studying service quality, Frochot and Hughes (2000) showed that the assessment of quality for services is more complicated and complex than for physical products because of the intrinsic characteristics of heterogeneity, inseparability of production and consumption, perishability and intangibility. Such intrinsic characteristics and the elusive concept of service make it hard to define and measure service quality.

Realizing the significance and influence of service quality on survival, success and growth of service industries as well as the difficulty in measuring service quality, many researchers devoted time to the development of generic instruments which could be widely employed to measure service quality across different service sectors. The plentiful methods provided in literatures (e.g., Erto & Vanacore, 2002; Franceschini & Rossetto, 1997; Parasuraman, Zeithaml, & Berry, 1985; Philip & Hazlett, 1997; Teas, 1994) can be roughly categorized into two types, as incident-based or attribute-based methods (Stauss & Weinlich, 1997). Among the successive variants of the latter, the SERVQUAL instrument has attracted the greatest attention.

Regarding the development of SERVQUAL instrument, also known as PZB service quality, the scale was proposed by Parasuraman et al. (1985), and refined in 1988, 1991 and 1994 (Akbaba, 2006). Parasuraman et al. (1985) conducted in-depth interviews with executives of service firms and customer focus groups, and then they made a definition of service quality as the gap between expectations and perceptions of customers, which is referred to as the P–E gap. A multiple-item scale for measuring ten dimensions of service quality was proposed. In measuring the score of the service quality, the discrepancy between the ratings that customers assigned to paired expectation and perception statements are calculated. By subtracting the aggregate expectation scores from

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the aggregate perception scores, the gap scores for each attribute are obtained. A positive gap shows that perception is better than expectation and thus exhibits good quality, while a negative gap exhibits poor quality. A neutral gap of zero score implies that the quality is satisfactory (Akbaba, 2006). The scale was later simplified to five dimensions in 1988. Further improvements to SERVQUAL were made in 1991 and 1994 (Parasuraman et al., 1985, Parasuraman, Zeithaml, & Berry, 1988, 1991, 1994a, 1994b).

The statistical analysis based on SERVQUAL instrument has been traditionally used as an effective tool for measuring service quality. Dissimilate to statistical analysis; fuzzy approach and analysis network process (ANP) technique are also applied to this field. Chien and Tsai (2000) used Hamming distance (Klir & Yuan, 1995) to compute the discrepancy rate between consumers' satisfaction degree and importance degree, which were quantified by triangular fuzzy numbers (TFNs). Tsaur, Chang, and Yen (2002) pointed out that the assessment results obtained from different daily decision-making problems of diverse intensity may be misleading if the fuzziness of subjective human judgment is not taken into account. Hence, they utilized fuzzy multiple criteria/attributes decision-making (MCDM) technique to deal with an airline service quality evaluation problem. In their study, 15 attributes included in five aspects were used to assess the perceptions of performance for three airlines. TFNs were used to quantify the perceptions expressed by five linguistic variables and AHP weighting method (Saaty, 1980) was used to determine the preference weights for attributes. Benitez, Martin, and Roman (2007) conducted an empirical study for measuring the experimented quality of service under 13 attributes in three hotels of the LHR chain. TFNs were used to quantify the linguistic expression varying from four linguistic variables. The best nonfuzzy performance values were derived and used to compare and rank the service quality of hotels. Hsieh, Lin, and Lin (2008) applied ANP to evaluate the service quality under 23 criteria for four hot spring hotels in Taiwan and determine the ranking order of the hotels by weighted scores.

It was found that service quality components are the performance drivers of a service industry. Service quality components translate into the day-to-day activities that can be manipulated by management (Wilkins, Merrilees, & Herington, 2007). Hence, investigating service quality and tracking the trends periodically would definitely help managers to formulate effective strategies for improving service quality. As fuzzy set theory has been extensively employed to the decision-making problems, however, its application in the field of service quality management is still rare. The purpose of this study is to propose a fuzzy analysis architecture, which consists of fuzzy measurement of P–I gap based on SERVQUAL instrument, modified P–I analysis for attributes and ranking order determination for subjects, to address service quality management more effectively by including the vagueness of evaluators' judgment and identifying directions and targets for improvement. An empirical study is conducted by using the proposed analysis architecture. The rest of this paper is organized as follows. Section 2 describes the modification/adaptation of SERVQUAL. In Section 3, the proposed analysis architecture is presented. Section 4 conducts an empirical study. Finally, Section 5 contains some conclusions.

2. Modification and adaptation of SERVQUAL

Although the authors of SERVQUAL has applied refinement to the original SERVQUAL instrument, and they held that the dimensions identified were transferable across business sectors, researchers still keep expressing the theoretical and operational concern and criticisms about the scale (e.g., Buttle, 1996). For empirical application, Buttle argued that the numbers and contents of dimensions are varied in reality according to the sector under study. Vazquez, Bosque, Diaz, and Ruiz (2001) also pointed out that the scale and its dimensions require customization to the specific service sector in which they are applied. The research of Wilkins et al. (2007) also supports these findings.

Taking into account these criticisms, researchers also investigated alternative SERVQUAL formats, as one-column, two-column and three-column formats. If management wants plentiful data in the questionnaire analysis, respondents may be asked to rate three perspectives via a three-column format scale, including importance level of service, service quality expectations and perceptions. However, such a three-column questionnaire will induce respondents to take more time to complete it which is a disadvantage. Regarding the functions of three perspectives, Teas (1993) argued that expectations can be viewed as the ideal level of service, as the predictions of service, or as the importance of attributes, and these may induce somewhat of confusion in the measurement. Smith (1995) pointed out that measuring the importance of service attributes for customers may be more useful and meaningful to managers than measuring the expectations of customers. His study revealed that importance scores fit the gap-based service quality better than expectation scores. Smith argued that a number of researchers have substituted importance for expectations in SERVQUAL instrument. Landrum and Prybutok (2004) conducted a study of library service quality and success model. Their study indicated that difference score based on perception of performance minus expectation may be as useful to managers as that based on perception of performance minus importance, and more importantly, importance score may lead to less confusion. They proposed a two-column format consisting of importance and perception to measure variables related to information system success. Akbaba (2006) modified the SERVQUAL instrument to analyze the service quality expectations and perceptions of the business hotel's guests. Customers were asked to rate the attributes on a five-point scale. Some of the five dimensions confirmed in the work were different from SERVQUAL. The author indeed took importance as an indicator of the expectations in the analysis.

3. The proposed analysis architecture

In spite of the criticisms about SERVQUAL, it is still considered as a major tool for measuring service quality (Lam & Woo, 1997; Mittal & Lassar, 1996) and the modified/adapted version of SERVQUAL has been used as an effective tool to measure service quality across a broad range of service categories, such as supermarkets, information service and hotel industries (Akbaba, 2006; Landrum & Prybutok, 2004; Vazquez et al., 2001). Thereby, SERVQUAL is used to develop the measurement structure in this study. According to the methods utilized or suggested in the literatures (Akbaba, 2006; Landrum & Prybutok, 2004; Smith, 1995; Teas, 1993; Vazquez et al., 2001), two perspectives consisting of importance and perception are analyzed in this study. The importance rating exerts two functions on service quality assessment. First, the service quality measurement is based on perception rating (P) minus importance rating (I) and the difference is referred to as P–I gap score. Second, importance rating serves as the weight attached to the associated gap score. The original gap scores are weighted to provide the basis for ranking all subjects. Adopting importance rating to obtain P–I gap score, instead of using expectation rating (E) to obtain P–E gap score, can take advantage of reducing the confusion of interpretation about expectation rating.

The study of Landrum and Prybutok (2004) showed that some attributes that were rated high belonged to dimensions rated low, and some attributes rated low belonged to dimensions rated high. Managers may target inappropriate attributes if respondents rate only the dimensions. Hence, they suggested that if managers

Table 1
Linguistic variables along with quantified TFNs.

Linguistic data (Importance/Perception)	TFN
Very high/very good	(8, 10, 10)
High/good	(6, 8, 10)
Medium/fair	(3, 5, 7)
Low/poor	(0, 2, 4)
Very low/very poor	(0, 0, 2)

are concerned about the importance of different areas of service being provided, they should have respondents rate the importance of each attribute rather than the importance of each dimension. For these reasons, the rating and analysis are focused on the attributes in this study.

In the conventional method, the ratings of importance, expectation and perception are measured as if they were crisp data. Seven-point or five-point Likert scales are often used to collect the ratings of customers. Statistical method is then employed to draw inferences. However, service quality assessment problems, such as "how important are the attributes given to you" or "how you would rate the perception of performance of the attributes", are problems that adhere to group decision-making under multiple attributes and subjective judgment of preference, thereby, fuzzy sets theory is adequate to deal with them to strengthen the reasonableness and comprehension of measurement results. Regarding the subjective judgment of preference, lingual expressions, e.g., very good, fair and poor, are convenient and a natural representation. In this study, the ratings of importance and perception are expressed by linguistic variables. The linguistic data scheme in the rating set along with the quantified TFNs (Cochran & Chen, 2005; Liang & Wang, 1994) shown in Table 1 are used to capture the respondents' judgment and preference structure. For convenience, the momentous notations used in the following descriptions are listed in Table 2.

The computation flow of the proposed analysis architecture is shown in Fig. 1, which consists of three modules: fuzzy measurement of P–I gap, modified P–I analysis for attributes and ranking order determination for subjects. The procedure is carried in the following steps.

Initiation: Propose a suitable measurement structure for capturing service quality of the subjects under consideration.

3.1. Fuzzy measurement of P–I gap

Step 1: Obtain the linguistic ratings of service quality importance and perception for attribute q evaluated by respondent j of subject s. Then, quantify the linguistic judgment values as $\tilde{I}^s_{jq} = (a^s_{jq}, b^s_{jq}, c^s_{jq})$ and $\tilde{P}^s_{jq} = (\alpha^s_{jq}, \beta^s_{jq}, \gamma^s_{jq})$, respectively, where $j = 1, 2, \ldots, J$, $q = 1, 2, \ldots, Q$, $s = 1, 2, \ldots, S$.

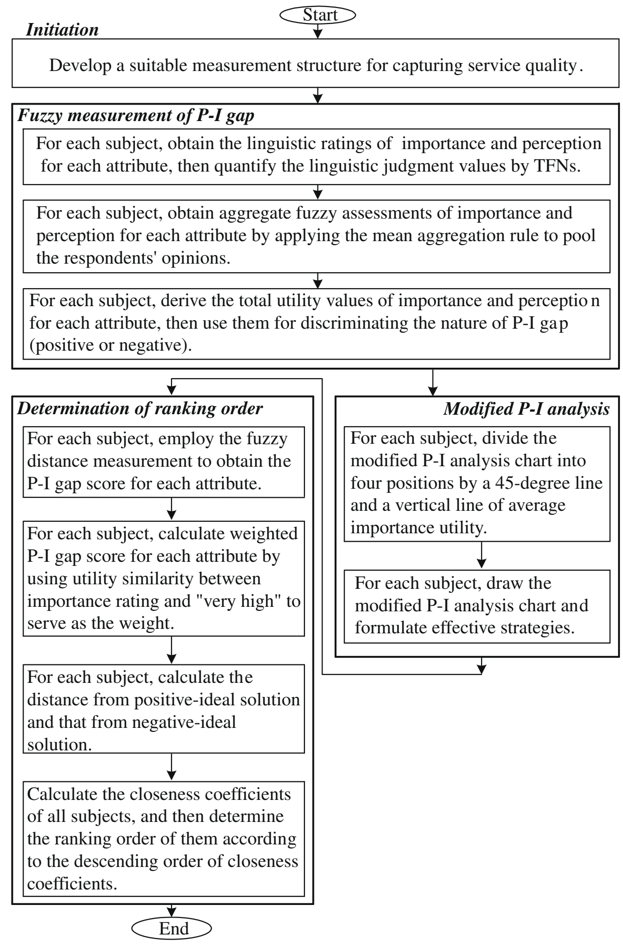

Fig. 1. Flowchart of the proposed analysis architecture.

Step 2: Apply the mean aggregation rule to pool the respondents' opinions. The aggregate fuzzy assessments of service quality importance and perception for attribute q of subject s will be $\tilde{I}^s_q = (a^s_q, b^s_q, c^s_q)$ and $\tilde{P}^s_q = (\alpha^s_q, \beta^s_q, \gamma^s_q)$, respectively, where

$$a^s_q = \sum_{j=1}^{J} a^s_{jq}/J, \quad b^s_q = \sum_{j=1}^{J} b^s_{jq}/J, \quad c^s_q = \sum_{j=1}^{J} c^s_{jq}/J,$$

$$\alpha^s_q = \sum_{j=1}^{J} \alpha^s_{jq}/J, \quad \beta^s_q = \sum_{j=1}^{J} \beta^s_{jq}/J, \quad \gamma^s_q = \sum_{j=1}^{J} \gamma^s_{jq}/J.$$

Table 2
Momentous notations.

s:	subject s, $s = 1, 2, \ldots, S$
j:	a customer who is selected as respondent j, $j = 1, 2, \ldots, J$
q:	attribute q used to evaluate service quality, $q = 1, 2, \ldots, Q$
$\tilde{I}^s_{jq} = (a^s_{jq}, b^s_{jq}, c^s_{jq})$:	a TFN used to quantify the linguistic judgment values of service quality importance for attribute q evaluated by respondent j of subject s
$\tilde{P}^s_{jq} = (\alpha^s_{jq}, \beta^s_{jq}, \gamma^s_{jq})$:	a TFN used to quantify the linguistic judgment values of service quality perception for attribute q evaluated by respondent j of subject s
$\tilde{I}^s_q = (a^s_q, b^s_q, c^s_q)$:	the aggregate fuzzy assessment of service quality importance for attribute q of subject s
$\tilde{P}^s_q = (\alpha^s_q, \beta^s_q, \gamma^s_q)$:	the aggregate fuzzy assessment of service quality perception for attribute q of subject s
$U_t(\tilde{I}^s_q)$:	total utility value of $\tilde{I}^s_q$. Referred to as importance utility for attribute q of subject s
$U_t(\tilde{P}^s_q)$:	total utility value of $\tilde{P}^s_q$. Referred to as perception utility for attribute q of subject s
$\bar{U}_t(\tilde{I}^s)$:	average importance utility of all attributes of subject s
$U_S(\tilde{I}^s_q, VH)$:	utility similarity between $\tilde{I}^s_q$ and "very high"
g^s_q:	gap score for attribute q of subject s
$\hat{g}^s_q$:	weighted gap score for attribute q of subject s
λ^s_q:	index of importance level for attribute q of subject s. $\lambda^s_q = 1$, if attribute q of subject s is of high importance; $\lambda^s_q = 0$, otherwise

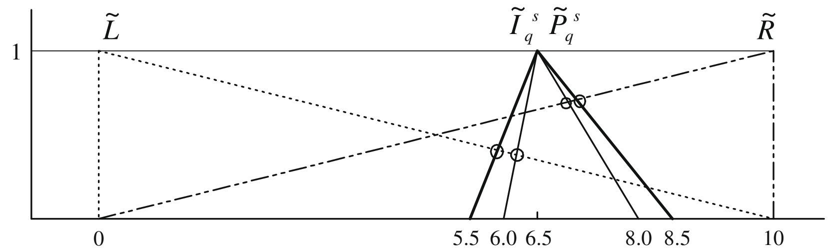

Fig. 2. Example of TFNs for calculating total utility values.

Step 3: Calculate the total utility values of $\tilde{I}_q^s$ and $\tilde{P}_q^s, U_t(\tilde{I}_q^s)$ and $U_t(\tilde{P}_q^s)$, respectively, and use them for discriminating the nature of P–I gap. For simplification, a gap with relation of $U_t(\tilde{P}_q^s) \geqslant U_t(\tilde{I}_q^s)$ is treated as a positive one; otherwise, as a negative one.

For obtaining $U_t(\tilde{I}_q^s)$ and $U_t(\tilde{P}_q^s)$, the definitions and formulas of right utility value based on maximizing set and left utility value based on minimizing set (Cochran & Chen, 2005; Hsieh & Chen, 1999) as well as the total utility function (Chen, 1985) are employed to calculate the total utility values as

$$U_t(\tilde{I}_q^s) = [U_R(\tilde{I}_q^s) + 1 - U_L(\tilde{I}_q^s)]/2, \quad s = 1,2,\ldots,S, \quad q = 1,2,\ldots,Q, \tag{1}$$

$$U_t(\tilde{P}_q^s) = [U_R(\tilde{P}_q^s) + 1 - U_L(\tilde{P}_q^s)]/2, \quad s = 1,2,\ldots,S, \quad q = 1,2,\ldots,Q, \tag{2}$$

where $U_R(\tilde{I}_q^s) = c_q^s/(10-(b_q^s - c_q^s))$ and $U_R(\tilde{P}_q^s) = \gamma_q^s/(10-(\beta_q^s - \gamma_q^s))$ denote the right utility values of $\tilde{I}_q^s$ and $\tilde{P}_q^s$, respectively, based on maximizing set (0,10,10) and $U_L(\tilde{I}_q^s) = (10-a_q^s)/(10+(b_q^s - a_q^s))$ and $U_L(\tilde{P}_q^s) = (10-\alpha_q^s)/(10+(\beta_q^s - \alpha_q^s))$ denote the left utility values of $\tilde{I}_q^s$ and $\tilde{P}_q^s$, respectively, based on minimizing set (0, 0, 10).

$U_t(\tilde{I}_q^s)$ and $U_t(\tilde{P}_q^s)$ are helpful information for clarifying the nature of P–I gap. Considering an example of $\tilde{I}_q^s = (6.0, 6.5, 8.0)$ and $\tilde{P}_q^s = (5.5, 6.5, 8.5)$ along with the associated maximizing set $\tilde{R} = (0, 10, 10)$ and minimizing set $\tilde{L} = (0, 0, 10)$ shown in Fig. 2. It is difficult to determine which of $\tilde{I}_q^s$ and $\tilde{P}_q^s$ is the larger one by straightforwardly comparing the membership functions. By using formulas (1) and (2), $U_t(\tilde{I}_q^s)$ is calculated as 0.6573 and $U_t(\tilde{P}_q^s)$ as 0.6496. The relation of $U_t(\tilde{P}_q^s) < U_t(\tilde{I}_q^s)$ reveals that the ranking of $\tilde{I}_q^s$ is superior to that of $\tilde{P}_q^s$, which induces that the gap is a negative one.

3.2. Modified P–I analysis

In order to formulate effective service strategies, Vazquez et al. (2001) employed the importance-performance analysis scheme, developed by Almanza, Jaffe, and Linn (1994) and referred to as I–P analysis, to obtain information on the strengths and weaknesses of the addressed supermarket retailing. By comparing the average perception of each dimension with the average perception of all dimensions, each dimension was assigned to high, medium or low perception. The same procedure was followed as with the perception for assigning each dimension to high, medium or low importance. By combining three groups (high, medium and low) of importance and perception, the chart was divided into a gray zone and four different positions, viz., competitive vulnerability, competitive strength, irrelevant superiority and relative indifference. The limitation of their I–P analysis is that perception ratings and importance ratings were, respectively, assigned to three groups. The P–I gap nature had not been incorporated into the position division. Hence, the quality status (good or poor) of each dimension can't be straightforwardly judged by the position where it was included. In this section, the I–P analysis is modified by dividing the positions by a 45-degree line and a vertical line of $\bar{U}_t(\tilde{I}^s)$ and then are referred to as modified P–I analysis in this paper. The modified scheme is shown in Fig. 3. For subject s, if the gap nature of attribute q is positive, i.e., $U_t(\tilde{P}_q^s) \geqslant U_t(\tilde{I}_q^s)$, then attribute q is included in the group above or on the 45-degree line; otherwise, below the 45-degree line. For positioning attribute q of subject s in respect of importance, the importance utility of attribute $q, U_t(\tilde{I}_q^s)$, is compared with $\bar{U}_t(\tilde{I}^s)$. If $U_t(\tilde{I}_q^s)$ is greater than or equal to $\bar{U}_t(\tilde{I}^s)$, then attribute q is included in the group of high importance; otherwise, in the group of low importance. Thus, an attribute included in position 1 indicates it is high importance with negative gap, in position 2 is high importance with positive gap, in position 3 is low importance with positive gap and in position 4 is low importance with negative gap. The steps for performing modified P–I analysis are as follows:

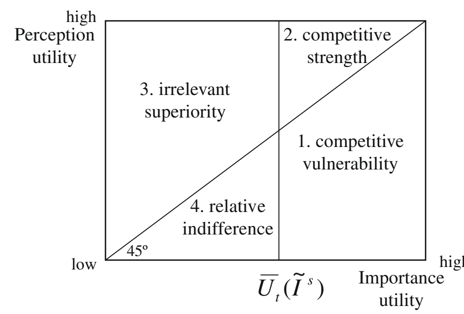

Fig. 3. Four positions of modified P–I analysis chart.

Step 4: For subject s, divide modified P–I analysis chart into four positions by a 45-degree line and a vertical line of $\bar{U}_t(\tilde{I}^s)$, where $\bar{U}_t(\tilde{I}^s)$ is calculated as

$$\bar{U}_t(\tilde{I}^s) = \frac{\sum_{q=1}^{Q} U_t(\tilde{I}_q^s)}{Q}, \quad s = 1,2,\ldots,S. \tag{3}$$

Step 5: Draw the points for all attributes of subject s in modified P–I analysis chart by using $U_t(\tilde{I}_q^s)$ and $U_t(\tilde{P}_q^s)$ corresponding to horizontal and vertical coordinate axes, respectively. Then, formulate effective strategies for each attribute according to the position included.

3.3. Ranking order determination

The underlying concept of Technique for Order Preference by Similarity to Ideal Solution (TOPSIS; Hwang & Yoon, 1981) is to choose the optimal alternative which is closest to the positive-ideal solution and farthest to the negative-ideal solution, meaning the optimal alternative has the best distance measurement. TOPSIS is a well-known method that can effectively deal with the MCDM problem by taking into account the closeness to both positive-ideal solution and negative-ideal solution. In this section, the gap score for attribute q of subject s is measured by the fuzzy distance between $\tilde{I}_q^s$ and $\tilde{P}_q^s$. Then, TOPSIS is employed with modifications of positive-ideal solution and negative-ideal solution to determine the ranking order of subjects with respect to the weighted gap scores of attributes. The ranking order of subjects can help managers understand the relative overall performance level of service quality.

The steps for determining the ranking order of subjects are as follows.

Step 6: Employ the distance measurement to obtain the difference between $\tilde{I}_q^s$ and $\tilde{P}_q^s$, i.e., P–I gap score for attribute q of subject s. By using the vertex method (Chen, 2000), the gap score is calculated as

$$g_q^s = \sqrt{\frac{1}{3}[(a_q^s - \alpha_q^s)^2 + (b_q^s - \beta_q^s)^2 + (c_q^s - \gamma_q^s)^2]},\quad s = 1,2,\ldots,S, \quad q = 1,2,\ldots,Q. \tag{4}$$

The results of Step 3 are used to discriminate the nature of g_q^s.

Step 7: Calculate the utility similarity between $\tilde{I}_q^s$ and "very high", $U_S(\tilde{I}_q^s, VH)$, to serve as the weight of g_q^s. By using the utility similarity method proposed by Hsieh and Chen (1999), the value can be calculated as

$$U_S(\tilde{I}_q^s, VH) = \frac{\min\{U_t(\tilde{I}_q^s), U_t(VH)\}}{\max\{U_t(\tilde{I}_q^s), U_t(VH)\}}, \quad s = 1,2,\ldots,S, \quad q = 1,2,\ldots,Q. \tag{5}$$

Then, the weighted gap score, $\hat{g}_q^s$, can be obtained as

$$\hat{g}_q^s = g_q^s \cdot U_S(\tilde{I}_q^s, VH), \quad s = 1,2,\ldots,S, \quad q = 1,2,\ldots,Q. \tag{6}$$

The reason for adopting weighted gap score is elaborated by an example of $\tilde{I}_q^1 = (6.0, 6.5, 8.0)$, $\tilde{P}_q^1 = (5.5, 6.5, 8.5)$, $\tilde{I}_q^2 = (7.0, 8.0, 9.5)$ and $\tilde{P}_q^2 = (6.5, 7.5, 9.5)$. By Step 3 and formula (4), both gaps, g_q^1 and g_q^2, are calculated as -0.4082. It seems that attribute q is assessed as the same quality level by the respondents of subjects 1 and 2. However, owing to the difference between $\tilde{I}_q^1$ and $\tilde{I}_q^2$, the two respondent groups should have different receptions for the gap. To rationally reflect such diversities, $U_S(\tilde{I}_q^1, VH)$ and $U_S(\tilde{I}_q^2, VH)$ are calculated from $\tilde{I}_q^1$ and $\tilde{I}_q^2$, respectively, and used as the weights attached to g_q^1 and g_q^2, respectively. By formula (5), $U_S(\tilde{I}_q^1, VH)$ and $U_S(\tilde{I}_q^2, VH)$ are calculated as 0.7171 and 0.8473, respectively. Thus, $\hat{g}_q^1$ and $\hat{g}_q^2$ are calculated as -0.2927 and -0.3459, respectively, by formula (6). The weighted gap scores deeply exhibit the different quality levels for attribute q by taking into account the different receptions of the two respondent groups.

Step 8: Determine the original positive-ideal solution of attribute q among all subjects as $\max_s\{\hat{g}_q^s\}$ and negative-ideal solution as $\min_s\{\hat{g}_q^s\}$. Then, derive the modifications of positive-ideal solution, $\hat{g}_q^{s+}$, and negative-ideal solution, $\hat{g}_q^{s-}$, according to the importance level for attribute q of subject s as $\hat{g}_q^{s+} = \lambda_q^s \cdot \max\{\max_s\{\hat{g}_q^s\}, 0\} + (1-\lambda_q^s) \cdot \min\{\max_s\{\hat{g}_q^s\}, 0\}$ and

$$\hat{g}_q^{s-} = \lambda_q^s \cdot \min_s\{\hat{g}_q^s\} + (1-\lambda_q^s) \cdot \min\{\min_s\{\hat{g}_q^s\}, 0\},\quad s = 1,2,\ldots,S, \quad q = 1,2,\ldots,Q. \tag{7}$$

For subject s, the distance from $\hat{g}_q^{s+}$ and that from $\hat{g}_q^{s-}$, denoted by d_s^+ and d_s^-, respectively, are calculated as follows:

$$d_s^+ = \sqrt{\sum_{q=1}^{Q}(\hat{g}_q^s - \hat{g}_q^{s+})^2} \quad \text{and} \quad d_s^- = \sqrt{\sum_{q=1}^{Q}(\hat{g}_q^s - \hat{g}_q^{s-})^2},\quad s = 1,2,\ldots,S. \tag{8}$$

In formula (7), if attribute q of subject s is of high importance, $\hat{g}_q^{s+}$ is restricted at least zero by the former term of $\hat{g}_q^{s+}$; otherwise, $\hat{g}_q^{s+}$ is restricted at most zero and should be greater than or equal to $\hat{g}_q^{s-}$ by the latter terms of $\hat{g}_q^{s+}$ and $\hat{g}_q^{s-}$. Such modifications keep the principle that if attribute q of subject s is of high importance, the larger the value of $\hat{g}_q^s$, the better the distance measurement; otherwise, the smaller the absolute value of $\hat{g}_q^s$, the better the distance measurement.

Step 9: Calculate the closeness coefficient of subject s, d_s^*. Then, the ranking order of all subjects is determined according to the descending order of closeness coefficients. d_s^* is calculated as

$$d_s^* = \frac{d_s^-}{d_s^+ d_s^-}, \quad s = 1,2,\ldots,S. \tag{9}$$

4. Empirical study

In this section, the service quality management for four regular chain supermarkets situated in different trade areas of Taichung City in central Taiwan is conducted by using the proposed analysis architecture in March 2008. For convenience, the supermarkets are denoted by store s, s = 1, 2, 3, 4. Measuring the service quality is a routine customer feedback process which is conducted by the

Table 3
Four dimensions consisting of 22 attributes.

Physical aspect	V1. The store has visually appealing buildings and facilities
	V2. The store's decoration, fixtures and equipment are pleasant, attractive and modern
	V3. The section design enables customers to move around with ease
	V4. The section layout enables customers to easily find the products they need
	V5. The sections are clean and bright
	V6. The parking lot enables customers to make a stop and move with ease
	V7. Employees are well dressed and appear neat
Reliability	V8. The store provides the services and goods as customers were promised and allows returns
	V9. There are always stocks of products/brands desired by customers
	V10. Waiting time at the cash registers is short
	V11. Employees show great interest and pleasure in resolving any customer problem
	V12. The store gives appropriate and punctual information on its sales promotions
Personal interaction	V13. Employees are always willing to advise customers on the best possible buy
	V14. Employees have in-depth knowledge to answer questions for customers
	V15. The public-contact staffs are always polite to customers
	V16. Employees are never too busy to respond to customer requests or complain
	V17. Employees kindly send their regards to customer
Policy	V18. The product prices are reasonable and clearly indicated
	V19. The store guarantees the freshness, hygiene and safety of products in its fruit and vegetable sections
	V20. The operating hours are convenient for customers
	V21. The store is characterized by its individual attention or help given customers
	V22. The store is characterized by periodically providing interesting sales promotions

stores under study. As the regional manager intends to assess the service quality of each store and determine the ranking order of four stores through periodic surveys with a small sample size, thereby a convenience sampling approach was utilized to select the small-sized customers immediately after their departure from the store as the respondents. For each store, 40 questionnaires were completed by the customers who were willing to fill them out. The TFNs scheme shown in Table 1 is used to quantify the judgment values of linguistic data. In the importance section, one of the five linguistic variables, viz., very high, high, medium, low and very low, is chosen by the individual respondents to capture the importance rating for each attribute; while in the perception section, one of the five linguistic variables, viz., very good, good, fair, poor and very poor, is chosen to capture the perception rating for each attribute.

4.1. The used dimensions and attributes

Initiation: The service quality dimensions for supermarket companies proposed by Vazquez et al. (2001), viz., physical aspects, reliability, personal interaction and policies, are employed to develop a suitable measurement structure for capturing service quality of the stores. By taking into account the business characteristics of the stores, the attributes of SERVQUAL and the those suggested by Vazquez et al. (2001) are referred by the storekeepers and regional manager to propose 22 attributes used in this study. Table 3 shows the four dimensions consisting of 22 attributes.

4.2. Implementation and findings

With the proposed attributes for measuring service quality, the proposed analysis architecture starts off as follows:

Steps 1 and 2: For example, the linguistic ratings of service quality importance and perception for attribute 1 evaluated by respondent 2 of store 3 are "very high" and "good", respectively. The TFNs for quantifying the linguistic judgment values are as $\tilde{I}^3_{21} = (8, 10, 10)$ and $\tilde{P}^3_{21} = (6, 8, 10)$, respectively. By pooling all respondents' opinions for all attributes, the aggregate fuzzy assessments of importance and perception are shown in Table 4.

Table 4
Aggregate fuzzy assessments of importance and perception.

Attribute (q)	Store 1		Store 2	
	$\tilde{I}^1_q$	$\tilde{P}^1_q$	$\tilde{I}^2_q$	$\tilde{P}^2_q$
1	(5.975, 7.975, 9.325)	(5.275, 7.275, 9.025)	(6.150, 8.150, 9.850)	(4.975, 6.975, 8.875)
2	(4.825, 6.825, 8.575)	(4.975, 6.975, 8.875)	(6.025, 8.025, 9.625)	(4.950, 6.950, 8.800)
3	(6.925, 8.925, 9.925)	(5.625, 7.625, 9.325)	(6.875, 8.875, 9.925)	(5.575, 7.575, 9.475)
4	(6.425, 8.425, 9.775)	(5.550, 7.550, 9.400)	(6.600, 8.600, 9.850)	(5.250, 7.250, 9.100)
5	(6.450, 8.450, 9.850)	(5.700, 7.700, 9.400)	(6.550, 8.600, 9.850)	(5.025, 7.025, 8.875)
6	(6.450, 8.450, 9.700)	(5.500, 7.500, 9.100)	(5.950, 7.950, 9.550)	(5.400, 7.400, 9.250)
7	(6.750, 8.750, 9.850)	(5.825, 7.825, 9.475)	(6.675, 8.675, 9.925)	(5.175, 7.175, 9.025)
8	(6.800, 8.800, 9.850)	(4.775, 6.775, 8.725)	(6.700, 8.700, 9.850)	(4.650, 6.650, 8.650)
9	(6.925, 8.925, 9.775)	(5.725, 7.725, 9.325)	(7.000, 9.000, 9.850)	(5.375, 7.375, 9.325)
10	(6.175, 8.175, 9.775)	(5.850, 7.850, 9.550)	(5.925, 7.925, 9.625)	(4.625, 6.625, 8.575)
11	(6.325, 8.325, 9.925)	(5.300, 7.300, 9.100)	(5.950, 7.950, 9.700)	(5.000, 7.000, 8.950)
12	(6.775, 8.775, 9.775)	(5.700, 7.700, 9.550)	(6.800, 8.800, 9.700)	(5.625, 7.625, 9.475)
13	(6.075, 8.075, 9.325)	(5.425, 7.425, 9.175)	(6.425, 8.425, 9.625)	(5.100, 7.100, 8.950)
14	(6.175, 8.175, 9.475)	(4.650, 6.650, 8.500)	(7.050, 9.050, 9.850)	(4.450, 6.450, 8.350)
15	(6.325, 8.325, 9.625)	(6.025, 8.025, 9.625)	(6.750, 8.750, 9.850)	(5.250, 7.250, 9.100)
16	(6.475, 8.475, 9.625)	(5.175, 7.175, 8.875)	(6.750, 8.750, 9.850)	(5.025, 7.025, 8.875)
17	(6.175, 8.175, 9.475)	(4.850, 6.850, 8.650)	(6.125, 8.125, 9.625)	(5.125, 7.125, 9.025)
18	(6.275, 8.275, 9.625)	(5.325, 7.325, 9.175)	(6.500, 8.500, 9.850)	(4.525, 6.525, 8.425)
19	(6.525, 8.525, 9.775)	(6.600, 8.600, 9.850)	(6.525, 8.525, 9.775)	(5.200, 7.200, 9.100)
20	(6.325, 8.325, 9.775)	(6.175, 8.175, 9.775)	(6.200, 8.200, 9.850)	(5.425, 7.425, 9.175)
21	(4.650, 6.650, 8.200)	(5.075, 7.075, 8.875)	(5.475, 7.475, 9.175)	(4.650, 6.650, 8.650)
22	(5.975, 8.050, 9.550)	(5.675, 7.675, 9.475)	(5.850, 7.850, 9.550)	(5.075, 7.075, 9.025)
	Store 3		Store 4	
	$\tilde{I}^3_q$	$\tilde{P}^3_q$	$\tilde{I}^4_q$	$\tilde{P}^4_q$
1	(5.850, 7.850, 9.550)	(5.825, 7.825, 9.475)	(6.200, 8.200, 9.700)	(4.975, 6.975, 8.875)
2	(5.350, 7.350, 9.100)	(5.550, 7.550, 9.250)	(5.675, 7.675, 9.175)	(4.525, 6.525, 8.425)
3	(6.525, 8.525, 9.625)	(4.825, 6.825, 8.725)	(6.725, 8.725, 9.925)	(5.250, 7.250, 9.100)
4	(6.425, 8.425, 9.925)	(5.550, 7.550, 9.250)	(6.350, 8.350, 9.700)	(5.225, 7.225, 9.025)
5	(6.325, 8.325, 9.775)	(5.950, 7.950, 9.700)	(6.150, 8.150, 9.550)	(4.975, 6.975, 8.875)
6	(5.775, 7.775, 9.475)	(6.250, 8.250, 9.850)	(6.450, 8.450, 9.850)	(5.600, 7.600, 9.400)
7	(6.700, 8.700, 10.000)	(5.800, 7.800, 9.400)	(6.325, 8.325, 9.775)	(5.600, 7.600, 9.250)
8	(6.575, 8.575, 9.775)	(5.275, 7.275, 9.025)	(6.500, 8.500, 9.700)	(5.525, 7.525, 9.325)
9	(6.800, 8.800, 9.850)	(5.375, 7.375, 9.175)	(7.000, 9.000, 9.850)	(5.175, 7.175, 9.025)
10	(6.275, 8.275, 9.925)	(5.075, 7.075, 9.025)	(6.100, 8.100, 9.700)	(4.575, 6.575, 8.575)
11	(6.225, 8.225, 9.775)	(5.100, 7.100, 8.950)	(6.075, 8.075, 9.625)	(4.925, 6.925, 8.725)
12	(7.175, 9.175, 9.925)	(5.925, 7.925, 9.475)	(6.950, 8.950, 9.850)	(5.425, 7.425, 9.175)
13	(6.650, 8.650, 9.850)	(5.400, 7.400, 9.250)	(6.225, 8.225, 9.625)	(5.425, 7.425, 9.175)
14	(6.200, 8.200, 9.550)	(5.900, 7.900, 9.550)	(5.775, 7.775, 9.325)	(5.600, 7.600, 9.250)
15	(6.725, 8.725, 9.775)	(5.675, 7.675, 9.175)	(6.450, 8.450, 9.850)	(5.500, 7.500, 9.400)
16	(7.050, 9.050, 10.000)	(5.025, 7.025, 8.875)	(6.600, 8.600, 9.850)	(5.550, 7.550, 9.250)
17	(6.750, 8.750, 9.850)	(5.625, 7.625, 9.175)	(6.150, 8.150, 9.550)	(5.650, 7.650, 9.400)
18	(6.600, 8.600, 9.850)	(5.150, 7.150, 8.950)	(6.325, 8.325, 9.775)	(5.550, 7.550, 9.250)
19	(6.500, 8.500, 9.850)	(5.650, 7.650, 9.250)	(6.500, 8.500, 9.700)	(4.700, 6.700, 8.500)
20	(6.225, 8.225, 9.775)	(5.175, 7.175, 9.025)	(5.900, 7.900, 9.700)	(5.575, 7.575, 9.325)
21	(5.725, 7.725, 9.325)	(4.200, 6.200, 8.200)	(5.325, 7.325, 9.025)	(4.175, 6.175, 7.975)
22	(6.275, 8.275, 9.625)	(4.825, 6.825, 8.725)	(6.300, 8.300, 9.700)	(5.275, 7.225, 8.925)

Step 3: For calculating the total utility values of $\tilde{I}_1^3$ and $\tilde{P}_1^3$, for example, the associated right utility values and left utility values are calculated beforehand as

$$U_R(\tilde{I}_1^3) = 9.550/(10 - (7.850 - 9.550)) = 0.816,$$
$$U_R(\tilde{P}_1^3) = 9.475/(10 - (7.825 - 9.475)) = 0.813,$$
$$U_L(\tilde{I}_1^3) = (10 - 5.850)/(10 + (7.850 - 5.850)) = 0.346 \text{ and}$$
$$U_L(\tilde{P}_1^3) = (10 - 5.825)/(10 + (7.825 - 5.825)) = 0.348.$$

Then, the total utility values are calculated by formulas (1) and (2) as

$$U_t(\tilde{I}_1^3) = (0.816 + 1 - 0.346)/2 = 0.735 \quad \text{and}$$
$$U_t(\tilde{P}_1^3) = (0.813 + 1 - 0.348)/2 = 0.733.$$

The relation of $U_t(\tilde{I}_1^3) > U_t(\tilde{P}_1^3)$ reveals that g_1^3 is a negative gap. The total utility values and nature of gaps are depicted in Table 5.

Steps 4 and 5: Calculate the values of $\bar{U}_t(\tilde{I}^1), \bar{U}_t(\tilde{I}^2), \bar{U}_t(\tilde{I}^3)$ and $\bar{U}_t(\tilde{I}^4)$ as 0.768, 0.780, 0.779 and 0.769, respectively, by formula (3). The modified P–I analysis charts along with effective strategies are provided in Fig. 4 and Table 6. To view the outcome as a whole, the results exhibit that the respondents among the four trade areas made different comments on the attributes. From the viewpoint of gap nature, there are merely three and two attributes of positive gap (good quality) for stores 1 and 3, respectively. Regarding the importance of attribute, the numbers of attribute included in group of high importance (positions 1 and 2) for stores 1 to 4 are 14, 13, 12 and 12, respectively. Among these attributes, 10 attributes (V3, V4, V7, V8, V9, V12, V15, V16, V18 and V19) are unanimously assessed with high importance. However, only one attribute (V19) is assessed with good quality in store 1. The regional manager should devise ways to help storekeepers improve service quality perceptions for these 10 attributes. On the contrary, the numbers of attribute included in group of low importance (positions 3 and 4) for stores 1–4 are 8, 9, 10 and 10, respectively. Among these attributes, four attributes (V1, V2, V10 and V21) are unanimously assessed with low importance. The resources or efforts attached to the attributes (V2, V6 or V21) of low importance and good quality for stores 1 or 3 could be shifted to the attributes of high importance yet poor quality.

Table 5
Total utility values and nature of gaps.

Attribute (q)	Store 1			Store 2		
	$U_t(\tilde{I}_q^1)$	$U_t(\tilde{P}_q^1)$	Nature of gap	$U_t(\tilde{I}_q^2)$	$U_t(\tilde{P}_q^2)$	Nature of gap
1	0.743	0.687	Negative	0.761	0.664	Negative
2	0.649	0.664	Positive	0.749	0.661	Negative
3	0.823	0.716	Negative	0.819	0.714	Negative
4	0.782	0.711	Negative	0.796	0.686	Negative
5	0.784	0.723	Negative	0.795	0.667	Negative
6	0.783	0.705	Negative	0.743	0.699	Negative
7	0.808	0.733	Negative	0.803	0.680	Negative
8	0.812	0.647	Negative	0.804	0.638	Negative
9	0.822	0.724	Negative	0.829	0.697	Negative
10	0.762	0.735	Negative	0.742	0.635	Negative
11	0.775	0.690	Negative	0.744	0.666	Negative
12	0.810	0.724	Negative	0.812	0.717	Negative
13	0.751	0.700	Negative	0.781	0.673	Negative
14	0.760	0.636	Negative	0.833	0.620	Negative
15	0.773	0.749	Negative	0.808	0.686	Negative
16	0.785	0.678	Negative	0.808	0.667	Negative
17	0.760	0.652	Negative	0.757	0.676	Negative
18	0.769	0.692	Negative	0.788	0.626	Negative
19	0.790	0.796	Positive	0.790	0.682	Negative
20	0.774	0.762	Negative	0.764	0.700	Negative
21	0.632	0.671	Positive	0.704	0.638	Negative
22	0.749	0.721	Negative	0.735	0.672	Negative
	Store 3			Store 4		
	$U_t(\tilde{I}_q^3)$	$U_t(\tilde{P}_q^3)$	Nature of gap	$U_t(\tilde{I}_q^4)$	$U_t(\tilde{P}_q^4)$	Nature of gap
1	0.735	0.733	Negative	0.763	0.664	Negative
2	0.693	0.710	Positive	0.719	0.626	Negative
3	0.789	0.651	Negative	0.807	0.686	Negative
4	0.783	0.710	Negative	0.775	0.683	Negative
5	0.774	0.744	Negative	0.758	0.664	Negative
6	0.729	0.768	Positive	0.784	0.715	Negative
7	0.805	0.730	Negative	0.774	0.714	Negative
8	0.794	0.687	Negative	0.787	0.709	Negative
9	0.812	0.696	Negative	0.829	0.680	Negative
10	0.771	0.672	Negative	0.756	0.631	Negative
11	0.766	0.673	Negative	0.753	0.658	Negative
12	0.844	0.740	Negative	0.825	0.700	Negative
13	0.800	0.699	Negative	0.765	0.700	Negative
14	0.762	0.739	Negative	0.728	0.714	Negative
15	0.806	0.719	Negative	0.784	0.707	Negative
16	0.834	0.667	Negative	0.796	0.710	Negative
17	0.808	0.715	Negative	0.758	0.719	Negative
18	0.796	0.677	Negative	0.774	0.710	Negative
19	0.788	0.717	Negative	0.787	0.639	Negative
20	0.766	0.680	Negative	0.740	0.712	Negative
21	0.724	0.600	Negative	0.691	0.595	Negative
22	0.769	0.651	Negative	0.771	0.684	Negative

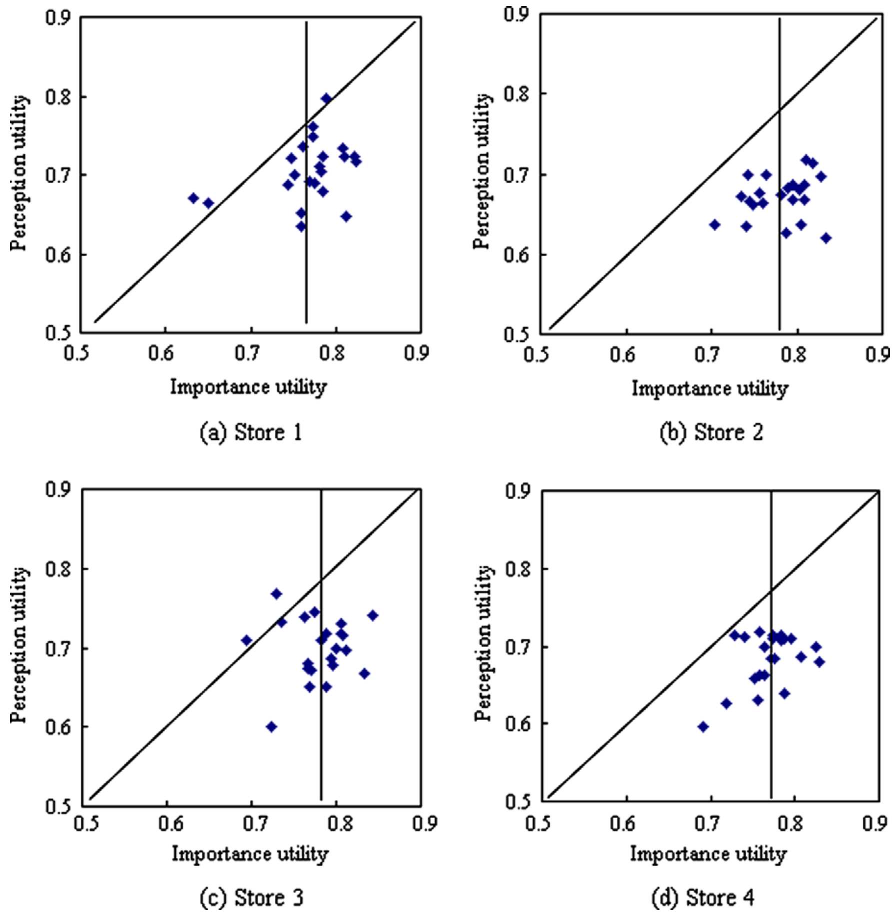

Fig. 4. Modified P–I analysis charts.

Table 6
Attributes included in different positions along with effective strategies.

	Position 1	Position 2	Position 3	Position 4
Store 1	V3, V4, V5, V6, V7, V8, V9, V11, V12, V15, V16, V18, V20	V19	V2, V21	V1, V10, V13, V14, V17, V22
Store 2	V3, V4, V5, V7, V8, V9, V12, V13, V14, V15, V16, V18, V19			V1, V2, V6, V10, V11, V17, V20, V21, V22
Store 3	V3, V4, V7, V8, V9, V12, V13, V15, V16, V17, V18, V19		V2, V6	V1, V5, V10, V11, V14, V20, V21, V22
Store 4	V3, V4, V6, V7, V8, V9, V12, V15, V16, V18, V19, V22			V1, V2, V5, V10, V11, V13, V14, V17, V20, V21
Strategy	Require a greater effort to reverse the nature of gap from negative to positive	Maintain the fine performance	Shift some efforts to the attributes included in position 1	Do not require much attention and concern

Steps 6 and 7: For example, the P–I gap score for attribute 1 of store 3 is calculated by formula (4) as

$$g_1^3 = \sqrt{\frac{1}{3}[(5.850 - 5.825)^2 + (7.850 - 7.825)^2 + (9.550 - 9.475)^2]}$$
$$= 0.048.$$

Since g_1^3 is a negative gap, the score of g_1^3 is treated as -0.048 in the following analysis. As the total utility value of "very high", $U_t(VH)$, is calculated as 0.917, the utility similarity between $\tilde{I}_1^3$ and "very high" is calculated by formula (5) as

$$U_S(\tilde{I}_1^3, VH) = \frac{0.735}{0.917} = 0.802.$$

By formula (6), $\hat{g}_1^3$ can be computed as $(-0.048) \cdot 0.802 = -0.038$. The weighted gap scores for the attributes of four stores are shown in columns 2–5 of Table 7.

Step 8: By using the positions of attributes shown in Table 6 and the original positive-ideal solution and negative-ideal solution shown in Table 7, λ_q^3 as well as the values of $\hat{g}_q^{3+}$ and $\hat{g}_q^{3-}$ determined by formula (7), for example, are depicted in Table 8. Then, the values of d_s^+ and d_s^- are calculated by formula (8) as d_1^+=3.351, d_1^-=3.459, d_2^+=4.952, d_2^-=1.137, d_3^+=3.943, d_3^-=2.998, d_4^+=3.857 and d_4^-=2.819.

Step 9: By formula (9), the closeness coefficients are calculated as $d_1^* = 0.508, d_2^* = 0.187, d_3^* = 0.432$ and $d_4^* = 0.422$. The ranking order of four stores is determined as store 1 $\succ$ store 3 $\succ$ store 4 $\succ$ store 2, meaning store 1 is the most effective, followed by stores 3, 4 and 2, respectively. The regional manager has assisted

Table 7
Weighted gap scores along with original positive-ideal solution and negative-ideal solution.

Attribute (q)	$\hat{g}_q^1$	$\hat{g}_q^2$	$\hat{g}_q^3$	$\hat{g}_q^4$	Original value	
					Positive-ideal solution	Negative-ideal solution
1	−0.484	−0.923	−0.038	−0.923	−0.038	−0.923
2	0.150	−0.816	0.140	−0.811	0.150	−0.816
3	−1.002	−0.976	−1.275	−1.140	−0.976	−1.275
4	−0.637	−1.028	−0.695	−0.844	−0.637	−1.028
5	−0.569	−1.201	−0.261	−0.857	−0.261	−1.201
6	−0.726	−0.390	0.353	−0.634	0.353	−0.726
7	−0.693	−1.165	−0.713	−0.561	−0.561	−1.165
8	−1.574	−1.589	−0.993	−0.708	−0.708	−1.589
9	−0.909	−1.231	−1.087	−1.415	−0.909	−1.415
10	−0.246	−0.989	−0.932	−1.158	−0.246	−1.158
11	−0.814	−0.721	−0.864	−0.882	−0.721	−0.882
12	−0.784	−0.857	−0.970	−1.174	−0.784	−1.174
13	−0.440	−0.979	−0.941	−0.587	−0.440	−0.979
14	−1.133	−2.084	−0.204	−0.119	−0.119	−2.084
15	−0.206	−1.145	−0.813	−0.700	−0.206	−1.145
16	−0.981	−1.337	−1.616	−0.803	−0.803	−1.616
17	−0.980	−0.732	−0.880	−0.345	−0.345	−0.980
18	−0.686	−1.556	−1.123	−0.592	−0.592	−1.556
19	0.065	−0.991	−0.667	−1.395	0.065	−1.395
20	−0.103	−0.620	−0.802	−0.277	−0.103	−0.802
21	0.360	−0.567	−1.109	−0.842	0.360	−1.109
22	−0.229	−0.563	−1.084	−0.814	−0.229	−1.084

Table 8
Values of $\lambda_q^3, \hat{g}_q^{3+}$ and $\hat{g}_q^{3-}$.

Attribute (q)	λ_q^3	$\hat{g}_q^{3+}$	$\hat{g}_q^{3-}$
1	0	−0.038	−0.923
2	0	0	−0.816
3	1	0	−1.275
4	1	0	−1.028
5	0	−0.261	−1.201
6	0	0	−0.726
7	1	0	−1.165
8	1	0	−1.589
9	1	0	−1.415
10	0	−0.246	−1.158
11	0	−0.721	−0.882
12	1	0	−1.174
13	1	0	−0.979
14	0	−0.119	−2.084
15	1	0	−1.145
16	1	0	−1.616
17	1	0	−0.980
18	1	0	−1.556
19	1	0.065	−1.395
20	0	−0.103	−0.802
21	0	0	−1.109
22	0	−0.229	−1.084

storekeepers of the stores with inferior rankings, i.e. stores 4 and 2, to devote more efforts to improve the service activities.

5. Conclusions

As service activities have become the fundamental and dominant factors of the economic system over the past three decades and the significance and influence of service quality have been recognized through the great effect on customer satisfaction and customer loyalty, studies in service quality started to increase. Relevant studies indicated that service quality is a critical element for survival and development in today's keen competition, and the significance and attention to service quality has grown noticeably. Many researchers are devoted to the development of generic instruments which would be widely employed to measure service quality across different service sectors. Among the plentiful methods provided in literatures, SERVQUAL instrument has attracted the greatest attention. In spite of the criticisms about SERVQUAL, it is still considered a leading tool for measuring service quality and the modified/adapted version of SERVQUAL has been widely used as an effective tool of analysis.

Nowadays fuzzy set theory has been extensively employed to the decision-making problems, however, its application in the field of service quality management is still rare. It should be noted that the assessment results obtained from MCDM problems of diverse intensity, such as service quality evaluation, may be misleading if the fuzziness of subjective human judgment is not taken into account. This paper develops an analysis architecture consisting of three modules to deal with service quality analysis problem by taking advantage of including the vagueness and subjectivity of evaluators' judgment. An empirical study is conducted by using the proposed approach.

The regional manager agrees that the proposed approach is helpful in identifying targets and formulating strategies for improving service quality. Thus it will be used to investigate service quality and track the trends periodically.

References

Akbaba, A. (2006). Measuring service quality in the hotel industry: A study in a business hotel in Turkey. *Hospitality Management, 25*, 170–192.

Almanza, B. A., Jaffe, W., & Linn, L. (1994). Use of the service attribute matrix to measure customer satisfaction. *Hospitality Research Journal, 17*, 63–75.

Benitez, J. M., Martin, J. C., & Roman, C. (2007). Using fuzzy number for measuring quality of service in the hotel industry. *Tourism Management, 28*, 544–555.

Buttle, F. (1996). SERVQUAL: Review, critique, research agenda. *European Journal of Marketing, 30*, 8–32.

Caruana, A. (2002). Service loyalty: The effects of service quality and the mediating role of customer satisfaction. *European Journal of Marketing, 36*, 811–830.

Chen, S. H. (1985). Ranking fuzzy numbers with maximizing set and minimizing set. *Fuzzy Sets and Systems, 17*, 113–129.

Chen, C. T. (2000). Extensions of the TOPSIS for group decision-making under fuzzy environment. *Fuzzy Sets and Systems, 114*, 1–9.

Chien, C. J., & Tsai, H. H. (2000). Using fuzzy numbers to evaluate perceived service quality. *Fuzzy Sets and Systems, 116*, 289–300.

Cochran, J. K., & Chen, H. N. (2005). Fuzzy multi-criteria selection of object-oriented simulation software for production system analysis. *Computers and Operations Research, 32*, 153–168.

Erto, P., & Vanacore, A. (2002). A probabilistic approach to measure hotel service quality. *Total Quality Management, 13*, 165–174.

Franceschini, F., & Rossetto, S. (1997). Design for quality: Selecting products' technical features. *Quality Engineering, 9*, 681–688.

Frochot, I., & Hughes, H. (2000). Histoqual: The development of a historic houses assessment scale. *Tourism Management, 21*, 157–167.

Ghobadian, A., Speller, S., & Jones, M. (1994). Service quality: Concepts and models. *International Journal of Quality and Reliability Management, 11*, 43–66.

Hsieh, C. H., & Chen, S. H. (1999). A model and algorithm of fuzzy product positioning. *Information Sciences, 121*, 61–82.

Hsieh, L. F., Lin, L. H., & Lin, Y. Y. (2008). A service quality measurement architecture for hot spring hotels in Taiwan. *Tourism Management, 29*, 429–438.

Hwang, C., & Yoon, K. (1981). *Multiple attributes decision making methods and applications*. New York: Springer.

Klir, G. J., & Yuan, B. (1995). *Fuzzy sets and fuzzy logic theory and applications*. NJ: Prentice-Hall, Englewood Cliffs.

Lam, S. S. K., & Woo, K. S. (1997). Measuring service quality: A test–retest reliability investigation of SERVQUAL. *Journal of the Market Research Society, 39*, 381–396.

Landrum, H., & Prybutok, V. R. (2004). A service quality and success model for the information service industry. *European Journal of Operational Research, 156*, 628–642.

Liang, G. S., & Wang, M. J. (1994). Personnel selection using fuzzy MCDM algorithm. *European Journal of Operational Research, 78*, 22–33.

McDougall, G. H. G., & Levesque, T. (2000). Customer satisfaction with services: Putting perceived value into the equation. *Journal of Services Marketing, 14*, 392–410.

Mittal, B., & Lassar, W. M. (1996). The role of personalization in service encounters. *Journal of Retailing, 72*, 95–109.

Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1985). A conceptual model of service quality and its implications for future research. *Journal of Marketing, 49*, 41–50.

Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1988). SERVQUAL: A multiple-item scale for measuring consumer perceptions of service quality. *Journal of Retailing, 64*, 12–40.

Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1991). Refinement and reassessment of the SERVQUAL scale. *Journal of Retailing, 67*, 420–450.

Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1994a). Alternative scales for measuring service quality: A comparative assessment based on psychometric and diagnostic criteria. *Journal of Retailing, 70*, 201–230.

Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1994b). Reassessment of expectations as a comparison standard in measuring service quality: Implications for further research. *Journal of Marketing, 58*, 111–124.

Philip, G., & Hazlett, S. (1997). The measurement of service quality: A new P–C–P attributes model. *International Journal of Quality and Reliability Management, 14*, 260–286.

Saaty, T. L. (1980). *The analytic hierarchy process: Planning, priority setting*. New York: McGraw Hill International Book Co..

Smith, A. M. (1995). The consumer's evaluation of service quality: An examination of the SERVQUAL methodology. Doctoral Dissertation, University of Manchester, British Thesis Service, D189377.

Stauss, B., & Weinlich, B. (1997). Process-oriented measurement of service quality: Applying the sequential incident technique. *European Journal of Marketing, 31*, 33–55.

Su, Y. L. (2004). Customer satisfaction measurement practice in Taiwan hotels. *International Journal of Hospitality Management, 23*, 397–408.

Teas, R. K. (1993). Expectations, performance evaluation and consumer's perception of quality. *Journal of Marketing, 57*, 18–34.

Teas, R. K. (1994). Expectations as a comparison standard in measuring service quality: An assessment of a reassessment. *Journal of Marketing, 58*, 132–139.

Tsaur, S. H., Chang, T. Y., & Yen, C. H. (2002). The evaluation of airline service quality by fuzzy MCDM. *Tourism Management, 23*, 107–115.

Vazquez, R., Bosque, I. A. R. D., Diaz, A. M., & Ruiz, A. V. (2001). Service quality in supermarket retailing: Identifying critical service experiences. *Journal of Retailing and Consumer Services, 8*, 1–14.

Wilkins, H., Merrilees, B., & Herington, C. (2007). Towards an understanding of total service quality in hotels. *Hospitality Management, 26*, 840–853.