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ORIGINAL RESEARCH

Data envelopment analysis in service quality evaluation: an empirical study

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Abstract Service quality is often conceptualized as the comparison between service expectations and the actual performance perceptions. It enhances customer satisfaction, decreases customer defection, and promotes customer loyalty. Substantial literature has examined the concept of service quality, its dimensions, and measurement methods. We introduce the perceived service quality index (PSQI) as a single measure for evaluating the multiple-item service quality construct based on the SERVQUAL model. A slack-based measure (SBM) of efficiency with constant inputs is used to calculate the PSQI. In addition, a non-linear programming model based on the SBM is proposed to delineate an improvement guideline and improve service quality. An empirical study is conducted to assess the applicability of the method proposed in this study. A large number of studies have used DEA as a benchmarking tool to measure service quality. These models do not propose a coherent performance evaluation construct and consequently fail to deliver improvement guidelines for improving service quality. The DEA models proposed in this study are designed to evaluate and improve service quality within a comprehensive framework and without any dependency on external data.

Keywords Data envelopment analysis · Slack-based measure · Service quality · Perceived service quality index · SERVQUAL model

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Introduction

Tourism is an engine of growth in many developing countries and contributes to foreign earnings more than many other economic sectors. Customer satisfaction is one of the most important sources of competitive advantage in tourism and service quality has an important influence on customer satisfaction (Martín-Cejas 2006). Delivering service with a high level of perceived quality can enhance customer loyalty, thus improving customer retention (Hu et al. 2009). The effect of service quality on customer satisfaction and its influence on gaining competitive advantage is undeniable (Yang et al. 2011). Although many studies have been conducted to identify the most important dimensions of service quality, the research on the comprehensive evaluation of service quality has been limited. We propose a systematic and structured framework for service quality evaluation in the hospitality industry which can also be extended to a wide range of industries in the service sector of the economy. The proposed performance measurement system uses data envelopment analysis (DEA) to evaluate a set of peer entities called decision-making units (DMUs). DEA is a non-parametric mathematical modeling technique which requires very few assumptions and can be used in performance evaluation problems with complex relations between multiple inputs and multiple outputs. DEA can be used to provide a holistic view of service quality which is composed of multiple-item constructs.

The service quality measurement methods in the literature can be broadly categorized into two groups: incident-based and attribute-based methods (Stauss and Weinlich 1997). The incident-based methods capture and analyze the customer incident data during various contact situations (Ro and Wong 2012). The attribute-based methods measure the quality of service on different dimensions. The SERVQUAL instrument is one of the most popular attribute-based research methods used in service quality measurement (Chou et al. 2011; Gilbert and Wong 2003; Lupo 2013; Tsang and Qu 2000). The SERVQUAL instrument is widely used by both academics and practitioners despite numerous criticisms directed at the scale (Caruana et al. 2000). A great deal of literature has explored different ways of defining service quality, considering a variety of dimensions and measurement methods. We introduce the perceived service quality index (PSQI) as a single measure for evaluating the multiple-item service quality construct based on the SERVQUAL model. A DEA model with constant inputs is used to calculate the PSQI. Moreover, a non-linear programming (NLP) model is developed to suggest guidelines for elevating service quality to a desirable level. DEA models have been used in the literature to measure service quality, but they do not provide a coherent performance evaluation construct and thus fail to delineate improvement guidelines for improving service quality.

Assaf and Magnini (2012) used the distance stochastic frontier method and a balanced sample of leading hotel chains in the US to measure the hotel efficiency scores and examine the effects of customer satisfaction on the hotel rankings. They concluded that there is a significant difference between the efficiency results derived from the models that include customer satisfaction and those that exclude customer satisfaction.

Sigala (2004) illustrated the value of stepwise DEA for measuring and benchmarking hotel productivity as well as the advantage of using DEA for measuring service quality. She also analyzed some broader issues regarding productivity measurement. She extended the current DEA applications by developing a stepwise approach to DEA that combined correlation with DEA analysis. Chang (2008) investigated the relationship between service quality and customer value, and explored the internal composition of this relationship in the hotel industry. Functional value was found to be affected mainly by reliable instances and accuracy of service quality, whereas conditional value was influenced by the responsiveness of service quality. Furthermore, emotional value was found to be affected mainly by the empathy engendered by service quality, while social value was influenced by tangible instances of service quality. Finally, epistemic value is affected by the responsiveness of service quality. Monfared and Safi (2013) developed a novel two-stage network DEA model to evaluate the relative efficiency of teaching quality and research productivity in universities. The proposed model was tested at Alzahra University in Iran and showed that it performs better than three alternative single-stage models.

Hsieh and Lin (2010) utilized relational network DEA to construct a model to analyze the efficiency and effectiveness of international tourist hotels in Taiwan. They evaluated the different production processes within the hotel and studied the relationships between efficiency, effectiveness, and overall performance. Finally, they recommended ways for enhancing the overall performance of the hotel industry in Taiwan. Cheng et al. (2010) improved the SBM of efficiency in context-dependent DEA and applied and measured the performance of selected hotels in Taiwan. They conducted an empirical study and concluded that the market differentiates five performance levels forming the benchmark structure for the hotel in their study. Hsieh et al. (2010) applied DEA to measure the operational efficiency and effectiveness in the Taiwanese hotel industry. Their proposed performance measurement model used the multi-criteria optimization and compromise solution method (Opricovic 1998) combined with measuring the entropy of the weights of the criteria.

Chiu et al. (2010) used DEA to investigate the operating efficiency of Taiwanese Hotels under different efficient frontier systems. They concluded that the efficiency of chain-operated hotels is higher than the efficiency of independent-operated hotels; assessing different frontier systems in the same way can misrepresent an efficient reference set; and some inefficient hotels are mistaken as being efficient if the hotels are treated as independent samples. Shyu and Hung (2012) developed a three-stage DEA model for the hotel industry in Taiwan. Three models were tested to explore the operation factors determining the management performance. Their empirical results showed that group operation is not the main determinant of operation efficiency of international tourist hotels, whereas small-scale hotels and chain hotels have significantly superior operational efficiency. They showed that using their three-stage DEA model, the management can avoid inefficient resource distribution decisions and enhance managerial efficiency. Talluri et al. (2013) examined the compatibility of operating efficiency and service quality by utilizing a combination of DEA and survey-based empirical research methods in the service driving agencies based on the actual transaction data. Their analysis revealed important strategic decision-making implications for service operations managers and provided novel insights for academic research. A large number of studies have used DEA as a benchmarking tool to measure service quality. These models do not propose a coherent performance evaluation construct and consequently fail to deliver improvement guidelines for improving service quality. The DEA models proposed in this study are designed to evaluate and improve service quality within a comprehensive framework and without any dependency on external data. Subjective variables have been widely used in mathematical models in different studies such as market analysis (Nasrabadi et al. 2013), decision making (Hosseini and Tarokh 2013) and service quality evaluation (Soteriou and Stavrinides 1997).

The remainder of this paper is organized as follows. In "Literature review", we review the service quality evaluation models in the literature. In "Data envelopment analysis", we present the mathematical details of the DEA model proposed in this study. In "Empirical study", we present an empirical study to demonstrate the applicability and exhibit the efficacy of the procedures in the proposed method. "Conclusion and future research directions" outline our conclusions and future research directions.

Literature review

Service quality models

Considering three main characteristics of services: intangibility, heterogeneity and inseparability, it is difficult to assess service quality. There are many tangible ways to judge goods quality, but tangible evidence is limited in the assessment of equipment, facilities and employees. In the absence of tangible aspects, customers must consider other intangible aspects of services. Consequently, the evaluation of this elusive and indistinct construct becomes very difficult (Parasuraman et al. 1985). Several attempts have been made to conceptualize service quality constructs. A common approach among researchers is to compare customer expectations with his/her perceptions of services (Grönroos 1984; Parasuraman et al. 1985).

Among various proposed constructs, the SERVQUAL scale has been widely used by researchers in various service industries. Parasuraman et al. (1985) conducted an exploratory qualitative study using focus group interviews with customers and in-depth interviews with the executives. They developed a multi-item conceptual model of service quality based on a set of gaps so that the fifth gap (the gap between expected service and perceived service) is a function of the gaps related to the service provider side. They proved that perceived service quality is the result of the consumer's comparison of expected service with perceived service.

Parasuraman et al. (1985) proposed a SERVQUAL scale with 5 dimensions (i.e., reliability, tangibles, responsiveness, empathy, and assurance) and 22 items for assessing service quality and balancing customer perceptions and expectations as follows:

- *Reliability* performing and fulfilling services accurately and as they promise.
- *Tangibles* appearance and tidiness of facilities, assets and personnel.
- *Responsiveness* accountability and willingness of personnel's and providing prompt services.
- *Empathy* taking individualized notice and intimacy with customers.
- *Assurance* setting up trust in customers and competence of employees to inject confidence to customer.

According to Parasuraman et al. (1985), the service quality is a function of perception and expectation of customers and can be modeled as:

$$\mathrm{SQ}_i = \sum_{j=1}^{k} (P_{ij} - E_{ij}) \tag{1}$$

where:SQ = Overall perceived service quality by individual i, P = Perception of individual i with respect to service quality item j, E = Expectation of individual i with respect to service quality item j, and K = Number of attributes.

Negative gaps mean perceived quality is less than satisfactory, zero gaps mean service quality is satisfactory and positive gaps mean perceived service quality is more than satisfactory (Parasuraman et al. 1985). The service quality literature shows that SERVQUAL as a standard scale for assessing service quality has been used to a large extent by researchers and service providers and has attracted a great deal of attention in recent years (Mei et al. 1999).

Hotel service quality

The hotel industry is highly sensitive to economic cycles due to demand fluctuation (Chen and Yeh 2011). The lack of service quality standards and the constant interactions between guests and employees have added more complexity to service quality evaluation in the hotel industry. Hoteliers, who once were concerned about the tangible aspect of their operations are now more concerned about service quality improvement. In a highly competitive tourism and hotel market environment, it is necessary for hoteliers to learn about their customer expectations and take corrective measures to improve their services and customer satisfaction.

Several studies have been conducted in the hotel industry to explore the service quality dimensions from the customer's viewpoint. Some of them reported the usual five dimensions of SERVQUAL construct for service quality in hotels (Fick and Ritchie 1991; Knutson et al. 1990). Other studies explored different dimensions for hotel service quality (Akan 1995; Akbaba 2006; Ekinci et al. 1998; Mei et al. 1999; Saleh and Ryan 1991; Wilkins et al. 2007). Recently, Kuo et al. (2012) studied problem solving, empathy, enthusiasm and friendliness as a way to measure hotel service quality; and Ladhari (2011) explored tangibility, reliability, responsiveness, confidence and communication as hotel service quality dimensions.

Related literature shows that dimensions of hotel service quality may differ from one segment of the hotel industry to another (Akbaba 2006). The literature also shows that expectations of hotel service quality differ from culture to culture (Armstrong et al. 1997), and some personal factors such as nationality affect customer expectation in the hotel industry services (Ariffin and Maghzi 2012).

Considering concerns about using SERVQUAL in hotel industry, an extensive study was done in nine five star hotels in Tehran, Iran to investigate the dimensions of hotel service quality from the customer viewpoint. Using exploratory factor analysis, five service quality dimensions of "tangibles", "problem solving", "service supply", "empathy", and "security" were identified. The validity and reliability of the scale were also verified (Najafi et al. 2013). Table 1 shows the five dimensions and their respective service quality attributes.

Table 1 Dimensions and items of hotel service quality

Dimension	Item	
Tangibles	Q1	Internal decoration (floor, ceilings, furniture, corridors) is stylish
	Q2	External hotel region (gardens, parking, buildings) is scenery
	Q3	Hotel is outfitted with modern and easy to use equipment
	Q4	Facilities and equipment of rooms are comfortable, clean and relaxing
	Q5	Equipment works well without any breakdown
	Q6	Public areas are quite clean
	Q7	Food and beverage served is completely sanitary
	Q8	Employees' appearance is always neat
Service supply	Q11	Employees Never linger guests
	Q15	Hotel tries to minimize all delays
	Q16	The hotel keeps records accurately
	Q17	All materials needed to provide services are enough
	Q21	Employees always treat politely especially when guests complain
	Q23	Hotel services scheduling is flexible and proportionate to guests
Empathy	Q24	The hotel tries to support guests in conflicts
	Q25	Employees notice to guests before they require
	Q26	Employees try to provide pleasant experience by heart
	Q27	Employees give individualized attention to guests
	Q28	The hotel's services are in accordance with guests' needs and desire
	Q29	Employees understand customers' specific needs rapidly
Problem solving	Q9	Employees seem young
	Q10	Employees are willing to solve guests' problems
	Q12	Employees know when and how services provide
	Q13	Employees listen to customers' requests with patience
	Q14	Guests can easily express their criticism
	Q18	All services completed as promised
Security	Q19	Hotel completely protects the personal privacy of the guests
	Q20	All security measures are considered by hotel
	Q22	Guests have trust and confidence to Employees

Methods for evaluating service quality

Assessing service quality using the SERVQUAL scale has been conducted by several researchers. The analysis of SERVQUAL data has also been done through an item-by-item and dimension-by-dimension analysis based on the gap method (Buttle 1996). The most frequently used methods for SERVQUAL evaluation are statistical analysis, multi-criteria decision making, fuzzy set theory, and DEA.

Statistical methods have been traditionally applied to compare customer's expectations and perceptions of services. As an instance, in a study conducted by Akbaba (2006) in the hotel industry, the paired-samples t tests between the respective expectation means and perception means of all service quality attributes showed that they were significantly different. Similar methods for evaluating service quality have been applied in different contexts such as private hospitals (Zarei et al. 2012), the banking industry (Kumar et al. 2009), the airline industry (Chau and Kao 2009), and the education industry (Bahadori et al. 2011).

Saleh and Ryan (1991) investigated the application of SERVQUAL in the hotel industry and found that the gap between expectation and perception in the services offered is a source of guests' dissatisfaction. Other researchers not only analyzed the gap but also explored the meaningful dimensions in hotel service quality using factor analysis (Akbaba 2006; Kuo et al. 2012; Saleh and Ryan 1991). Various regression models have also been developed to assess the relative importance of the factors in predicting customer satisfaction with the service quality offered by the particular hotels (Akan 1995; Akbaba 2006; Mei et al. 1999). Ladhari (2009) examined the validity and reliability of lodging quality index using data gathered from 200 Canadian respondents who had stayed in a hotel in Canada. Their quality index structure suggests that "tangibility" and "communication" are the most important dimensions in predicting "overall service quality", "cognitive satisfaction", "emotional satisfaction", "recommendation", "loyalty", and "willingness to pay a premium price".

Similarly, other studies have been conducted to explore the casual relationship between hotel service quality and the other related salient variables using structural equation modeling (Kwortnik and Han 2011). Batista et al. (2014) investigated the impact of service quality on customer satisfaction and loyalty among hotel customers. Results showed that hotel service quality and handling guest complaints are the most influential variables in guest satisfaction.

Other researchers have used multi-criteria decision making for SERVQUAL assessment. This category of studies focuses on prioritizing service quality attributes using different decision-making matrices and measurements with alternatives and attributes (Chen 2011; Lin 2010).

Shieh et al. (2010) identified major criteria of hospital service quality and causal relationships among them in Taiwan using SERVQUAL. They then used the decision-making trial and evaluation laboratory (DEMATEL) to identify the importance of each criterion to the management of the hospital. Awasthi et al. (2011) presented a hybrid approach based on SERVQUAL and fuzzy TOPSIS and evaluated service quality of four metro lines in Montreal. Using fuzzy TOPSIS, the alternatives were ranked based on the overall performance score of service quality. Chou (2009) proposed a multiple criteria decision-making method based on SERVQUAL for the evaluation of airport service quality by considering the importance weight of each service item. Fuzzy set theory has also been used in service quality research. Chien and Tsai (1998) measured the gap between customer's satisfaction and importance of quality items using the Hamming distance and Dubois's method instead of using difference scores (perceptions minus expectations). Wu et al. (2004) applied a fuzzy linguistic framework to measure the overall effectiveness of linking the market position and strategy of service quality for five hospitals. Chou et al. (2011) established a fuzzy weighted SERVQUAL model for evaluating the service quality and a case study of Taiwanese airline was conducted to illustrate the proposed fuzzy weighted SERVQUAL model.

Satapathy and Mishra (2013) introduced a framework for system design requirements in electricity utility service to measure service quality. They used artificial neural network to find the important areas for improvement and applied quality function deployment to design a new electricity industry. They then used interpretive structural modeling to assess the relationship between the design requirements. Zoraghi et al. (2013) employed a fuzzy multi-criteria decision-making model to evaluate service quality in hotels. They considered both subjective and objective weights to rank five hotels in Tehran. Three experts expressed their opinion on the alternatives according to seven service quality criteria. Their subjective method considered the expert judgments and fuzzy numbers were applied to deal with the ambiguity of their judgments. On the other hand, their objective method determined the criteria weights by mathematical modeling. The results showed the relative merits of their proposed model over similar methods in the literature.

Carrasco et al. (2012) developed a fuzzy model based on semantic translation under the perspective of the SERVQUAL instrument and assessed the quality of e-financial services.

More recently, DEA has also been used to measure service quality in the service sector of the economy. Manandhar and Tang (2002) categorized DEA models for benchmarking of bank branches into "operating efficiency", "service quality efficiency", and "profitability efficiency".

The service quality efficiency models often focus on the use of resources in providing service quality to customers (Bessent et al. 1984; Chilingerian and Sherman 1990; Sherman and Zhu 2006; Soteriou and Stavrinides 1997; Soteriou and Zenios 1999). Soteriou and Stavrinides (1997) developed a service quality model that can be used to assess the degree of optimal utilization resources and bank branches. Their study does not attempt to develop service quality measures, but rather tries to show how such measures can be incorporated into a model that can provide guideline towards service quality improvement. The model inputs consist of consumable resources such as the number of personnel, working space, time, and the number of account types. The output of the model is the perceived service quality of the branch personnel. The benchmarking of branches is based on how well they convert resources to achieve the level of service quality perception from the personnel viewpoint.

Lee and Kim (2014) proposed a DEA model based on SERVQUAL/SERVPERF to measure the overall service quality in firms using five dimensions of SERVQUAL/SERVPERF as outputs. In this model, the overall service quality of a DMU is not measurable unless it is benchmarked with some other DMUs. In addition, this relative single measure does not show the total service quality of a firm, because customer expectations have not been considered in their model.

Data envelopment analysis

DEA is a non-parametric mathematical programming method for measuring the relative efficiency of DMUs with multiple inputs and outputs that does not require any assumptions about a priori information on the importance of inputs and outputs. The advantage of non-parametric approaches is that they do not assume functional forms of the frontier. The definition of a DMU is generic and flexible and includes different consumable or non-consumable inputs and outputs. A set of weights are determined and the outputs and inputs are aggregated separately with regard to these weights to form a ratio as efficiency (Cooper et al. 2007).

Consider n DMUs, each transforming varying amounts of m different inputs to produce s different outputs. Specifically, $\mathrm{DMU_p}$ consumes amount x_{ip} of input $(i = 1,\ldots,m)$ and produces amount y_{rp} of output $(r = 1,\ldots,s)$. Assume that $x_{ij} \geq 0$ and $y_{rj} \geq 0$ and each DMU has at least one positive input and one positive output value. The standard input-oriented Charnes–Cooper–Rhodes (CCR) model is:

$$\begin{aligned}
&\text{Max} \quad \sum_{r=1}^{s} \mu_r y_{rp} \\
&\text{Subject to:} \\
&\sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} = 1 \qquad \forall j \\
&\sum_{i=1}^{m} v_i x_{ip} = 1 \\
&\mu_r, v_i \geq 0 \qquad \forall r, i
\end{aligned} \tag{2}$$

The standard CCR models allow each DMU to obtain the best weights and efficiencies (Charnes et al. 1978). The original DEA model measures the efficiency of DMUs radially and it does not consider slack values while the SBM is a non-radial method that measures the efficiency based on the slack values. A SBM efficiency score is introduced to calculate the efficiency and slack values together. The SBM efficiency indexρ is obtained from the following fractional problem in terms of slack values (Tone 2001).

$$\begin{aligned}
&\min \quad \rho = \frac{1 - (1/m)\sum_{i=1}^{m} s_i^- / x_{ip}}{1 - (1/s)\sum_{r=1}^{s} s_r^+ / y_{rp}} \\
&\text{subject to:} \\
&\sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = x_{ip} \quad \forall i \\
&\sum_{j=1}^{n} \lambda_j y_{rj} - s_r^+ = y_{rp} \quad \forall r \\
&\lambda_j, s_i^-, s_r^+ \geq 0 \qquad \forall j, i, r
\end{aligned} \tag{3}$$

The indexρ has a value between 0 and 1. A DMU is efficient if and only if $\rho^* = 1$. In this case, all slacks of the respective DMU are zero and the DMU is located on the efficient frontier. The above formulation can be transformed into a linear program using the Charnes–Cooper transformation (Tone, 2001) as follows:

$$\begin{aligned}
&\min \quad \tau = t - (1/m)\sum_{i=1}^{m} \bar{x}_i / x_{ip} \\
&\text{subject to:} \\
&1 = t + (1/s)\sum_{r=1}^{s} \bar{y}_r / y_{rp} \\
&t x_{ip} = \sum_{j=1}^{n} \Lambda_j x_{ij} + \bar{x}_i \qquad \forall i \\
&t y_{rP} = \sum_{j=1}^{n} \Lambda_j y_{rj} - \bar{y}_r \qquad \forall r \\
&\Lambda_j, \bar{x}_i, \bar{y}_r \geq 0 \qquad \forall j, i, r \\
&t > 0
\end{aligned} \tag{4}$$

The optimal solution for the above LP is $(\tau^*, t^*, \Lambda_j^*, \bar{x}_i^*, \bar{y}_r^*)$ and the optimal solution of the SBM can be defined as:

$$\rho^* = t^*,\ \lambda_j^* = \Lambda_j^*/t^*,\ s_i^{-*} = \bar{x}_i^*/t^*,\ s_j^{+*} = \bar{y}_j^*/t^* \tag{5}$$

Although DEA was originally developed for measuring efficiency of DMUs that consume several inputs to produce several outputs, DEA plays a broader role, as a tool for solving multiple criteria decision-making problems (Bouyssou 1999) and dealing with subjective variables. Also in the study model, the inputs do not transform into the outputs directly. Some DEA models require consistent input and output data (either high or low) (Lee and Kim 2012, 2014). A CCR model with a single constant input (or a single constant output) coincides with the corresponding Banker–Charnes–Cooper (BCC) model (Lovell and Pastor 1999). The CCR models without inputs (or without outputs) are meaningless. Pure output models have been used in different contexts such as service benchmarking (Lee and Kim 2012, 2014; Seol et al. 2007) and the application of target testing of bank services (Lovell and Pastor 1997). This study applies a model with constant inputs to aggregate the service quality perception into a single measure.

Model configuration for service quality evaluation

Grönroos (1982) identified two dimensions for service quality: technical quality and functional quality. Functional quality refers to the quality of service delivery, while technical quality indicates the outcome of the service. Quality evaluations are not only made solely on the outcome of a service; but also they involve the assessment of service delivery process (Parasuraman et al. 1985).

Customers with a certain amount of expectations come to receive a certain service. Their expectation of a service has been affected by word of mouth, personal needs and past experiences (Parasuraman et al. 1985). The key factor which determines the level of perceived quality is the process of service delivery. The DEA approach is an appropriate method for dealing with quality evaluation because service quality is a multiple-item construct and customers' evaluation is based on the process of service delivery.

In this paper, a DEA model is proposed to deal with service quality evaluation using the SERVQUAL method. We use a SBM of efficiency with constant inputs to calculate the PSQI. The SBM of efficiency is selected in this study because it allows for considering the slacks in the model and dealing with input excess and output shortfall directly. As a result, we can easily measure the exact amount of improvement needed with respect to each service quality attribute.

We define two DMUs and refer to them as the *expectation* and *perception* DMUs. The expectation and perception DMUs are used to determine the quality of services. To operationalize the model, the expectations and perceptions means of service quality items are considered as outputs, and a constant value of virtual input, 1, is assigned as the inputs of the DMUs. To measure PSQI, the following linear form of the SBM is considered:

$$
\begin{aligned}
&\min\ PSQI = t - (1/k)\sum_{i=1}^{k}\bar{x}_i\\
&\text{subject to:}\\
&1 = t + (1/k)\sum_{r=1}^{k}\bar{y}_r/P_r\\
&t = \Lambda_1 + \Lambda_2 + \bar{x}_i \qquad \forall i\\
&tP_r = \Lambda_1 E_r + \Lambda_2 P_r - \bar{y}_r \quad \forall r\\
&\bar{x}_i, \bar{y}_r \geq 0 \quad \forall i, r\\
&\Lambda_j \geq 0 \qquad j = 1,2\\
&t > 0
\end{aligned} \tag{6}
$$

where E_r and P_r ($r = 1,\ldots,k$) denote the expectations and perceptions means of k service quality items, respectively, and $\bar{x}_i, \bar{y}_r$ are the slack values. The PSQI is the efficiency of the perception DMU. It is important to note that only one of the DMUs is efficient at the same time. The following NLP formulation is developed based on SBM to propose suggestions for improving the service quality at a target or desired PSQI (DPSQI) level.

$$
\begin{aligned}
&\text{Min}\{\text{Max}(g_i)\} \quad \forall i\\
&\text{subject to:}\\
&1 = DPSQI + (1/k)\sum_{i=1}^{s} s_i/P'_i\\
&E_i - P'_i = g_i \qquad \forall i\\
&s_i = DPSQI.g_i \quad \forall i\\
&P'_i \geq P_i \qquad \forall i\\
&s_i,\ g_i \geq 0 \qquad \forall i
\end{aligned} \tag{7}
$$

The above model with minimax objective function consists of i variables. g_i can be modeled as a single linear programming using one additional variable c and i additional constraints as follows (Eiselt and Sandblom 2007):

$$
\begin{aligned}
&\text{Min}\ \ c\\
&\text{subject to:}\\
&c \geq g_i \quad \forall i\\
&1 = \text{DPSQI} + (1/k)\sum_{i=1}^{k} s_i/P'_i\\
&E_i - P'_i = g_i \qquad \forall i\\
&s_i = \text{DPSQI}.g_i \quad \forall i\\
&P'_i \geq P_i \qquad \forall i\\
&c,\ s_i,\ g_i \geq 0 \qquad \forall i
\end{aligned} \tag{8}
$$

A firm with customer expectations $E_i\,(i = 1,\ldots,k)$ and perceptions $P_i\,(i = 1,\ldots,k)$ for k service quality attributes should raise its customers' perceptions to $P'_i\ (i = 1,\ldots,k)$ to reach a given level of DPSQI. In cases where the firm attempts to fully fill the gaps, the DPSQI = 1, and the target level of customer perceptions is $E_i = P'_i\ (i = 1,\ldots,k)$. Obviously, improvement efforts can be considered when the PSQI < 1. Commonly, customers tend to rate their expectation high (Babakus and Boller 1992) and it is impossible to eliminate service quality gap completely in many service contexts. Therefore, in this model the DPSQI is considered less than 1 to represent a more realistic level for the service quality.

Tone (2001) defined the reference set of linear SBM model as the set of indices corresponding to positive λ_j to(x_0, y_0). The reference set R_0 is:

$$R_0 = \{j|\lambda_j^* > 0\}\ \ (j \in \{1,\ldots,n\}). \tag{9}$$

Table 2 The demographics of respondents ($N = 210$)

Attribute	Frequency	Percent
Gender		
Male	71	149
Female	29	61
Marital status		
Married	71	149
Single	23.3	49
Other	5.7	12
Age		
18–24	9	19
25–34	18.6	39
35–44	19	40
45–54	20.5	43
55–64	18.1	38
65 or above	14.8	31
Career		
Government employee	16.2	34
Self-employed	62.4	131
Retired	13.8	29
Student	6.2	13
Housewife	0.5	1
Other	1	2
Education level		
Illiterate	0.5	1
Elementary	7.6	16
Junior high school	6.7	14
High school	19	40
B.S/B.A	46.7	98
M.S/M.A	14.3	30
Ph.D	5.2	11
Purpose		
Remedial	10	21
Business	69	145
Recreation	12.9	27
Research	4.8	10
Other	3.3	7
Frequency of staying at hotels		
Less than once a year	10	21
Once a year	2.4	5
Twice a year	11.4	24
Three times a year	26.7	56
Four times a year	21.9	46
Five times or more a year	27.6	58
Annual income (US Dollar)		
Below 1,000	1	0.5
1,001–3,000	22	10.5
3,001–5,000	87	41.4
5,001–7,000	77	36.7
7,001–9,000	20	9.5
9,001–12,000	3	1.4
Above 12,000	1	0.5

The reference set of the linear SBM model (4) can be similarly defined as follows:

$$R_0 = \{j | \Lambda_j^* > 0\} \;\; (j \in \{1, \ldots, n\}). \tag{10}$$

We can suggest improvements when the perception DMU is inefficient or on the other hand PSQI < 1. In this case, the first DMU (expectation) is efficient and emerges as the reference set for the second DMU (perception), therefore, Λ_2 is equal to zero. Since virtual values are assigned as the inputs of the DMUs, access of inputs is meaningless. We replace $P_i\,(i = 1, \ldots, k)$ with $P'_i\;(i = 1, \ldots, k)$, put Λ_2 and $\bar{x}_i\;(i = 1,\ldots,k)$ equal to zero in Model (6), and transformed it to a NLP model.

Empirical study

An empirical study was conducted to assess the service quality of a five star international hotel situated in Tehran, Iran. A questionnaire with five dimensions and 29 items was designed based on the SERVQUAL. The SERVQUAL questionnaire uses a five-point Likert ranging from "very low" to "very high". In addition, the demographic attributes of the guests were also recorded in this questionnaire. The study samples were drawn from the pool of guests who stayed in this five star hotel in 2012. 300 questionnaires were administered to the hotel guests. Questionnaires were given to hotel guests on their day of departure. 90 questionnaires were not usable due to incomplete information and the remaining 210 questionnaires were processed for the purpose of this study resulting in a 70 % response rate. Table 2 presents the profile of the respondents and Table 3 presents the mean expectations, perceptions, and gaps of the service quality items.

Evaluation of hotel service quality

The SERVQUAL model was used to assess customer perceptions and expectations with regards to the five service quality dimensions and then evaluated the service quality by analyzing the gap between them. DEA was used on the collected data using the SERVQUAL method. The mean expectations and perceptions of 29 quality items were considered as the outputs of the expectations and perceptions DMUs, respectively, and the constant values of

Table 3 Mean expectations, perceptions and gaps of the service quality items ($N = 210$)

Dimension	Item	Perceptions mean	Expectations mean	Rounded gap means
Tangibles	Q1	3.84	4.93	−1.09
	Q2	3.87	4.94	−1.07
	Q3	3.81	4.91	−1.10
	Q4	3.87	4.95	−1.08
	Q5	3.93	4.96	−1.03
	Q6	3.85	4.91	−1.06
	Q7	3.82	4.93	−1.11
	Q8	3.90	4.96	−1.06
Service supply	Q11	3.69	4.95	−1.26
	Q15	3.67	4.85	−1.18
	Q16	3.70	4.86	−1.16
	Q17	3.73	4.86	−1.13
	Q21	3.79	4.87	−1.08
	Q23	3.70	4.87	−1.17
Empathy	Q24	3.82	4.95	−1.13
	Q25	3.70	4.92	−1.22
	Q26	3.77	4.97	−1.20
	Q27	3.73	4.95	−1.22
	Q28	3.79	4.94	−1.15
	Q29	3.71	4.91	−1.20
Problem solving	Q9	3.80	4.91	−1.11
	Q10	3.80	4.85	−1.05
	Q12	3.83	4.87	−1.04
	Q13	4.02	4.98	−0.96
	Q14	3.81	4.88	−1.07
	Q18	3.87	4.94	−1.07
Security	Q19	3.97	4.94	−0.97
	Q20	3.93	4.89	−0.96
	Q22	3.97	4.93	−0.96

Table 4 Level of customer service perception with respect to service quality dimensions

Dimension	PSQI	Ranking
Tangibles	0.782	3
Service supply	0.762	4
Empathy	0.760	5
Problem solving	0.787	2
Security	0.804	1

virtual input, 1, were assigned as the inputs in the DEA model. Model (6) was solved and $\text{PSQI} = 0.77$ was determined to represent the efficiency level.

In addition, the proposed model was used to evaluate the service quality in terms of quality dimensions. To accomplish this evaluation, the perceptions and expectations means of each dimension were considered as the outputs of the DMUs separately. The PSQIs of the service factors (Table 4) show the amount of customers' perceptions for the respective service dimension.

The ranking of service quality dimensions shows that the least PSQI is "Empathy" followed in descending order by "Service supply", "Tangibles", "Problem solving", and "Security".

Table 5 Service quality improvement suggestions for the hotel

Dimension	Item	P'_{Q_i} (0.8)	P'_{Q_i} (0.85)	P'_{Q_i} (0.9)	P'_{Q_i} (0.95)
Tangibles	Q1	3.94	4.18	4.44	4.69
	Q2	3.95	4.20	4.44	4.69
	Q3	3.92	4.17	4.42	4.67
	Q4	3.97	4.22	4.46	4.69
	Q5	3.97	4.22	4.46	4.72
	Q6	3.92	4.17	4.42	4.67
	Q7	3.94	4.18	4.44	4.69
	Q8	3.97	4.22	4.46	4.72
Service supply	Q11	3.97	4.22	4.46	4.69
	Q15	3.86	4.12	4.37	4.61
	Q16	3.88	4.12	4.37	4.61
	Q17	3.88	4.12	4.37	4.61
	Q21	3.88	4.13	4.39	4.63
	Q23	3.88	4.13	4.39	4.63
Empathy	Q24	3.97	4.22	4.46	4.69
	Q25	3.94	4.18	4.42	4.67
	Q26	3.98	4.24	4.48	4.72
	Q27	3.97	4.22	4.46	4.69
	Q28	3.95	4.20	4.44	4.69
	Q29	3.92	4.17	4.42	4.67
Problem solving	Q9	3.92	4.17	4.42	4.67
	Q10	3.86	4.12	4.37	4.61
	Q12	3.88	4.13	4.39	4.63
	Q13	4.02	4.24	4.48	4.74
	Q14	3.89	4.15	4.39	4.63
	Q18	3.95	4.20	4.44	4.69
Security	Q19	3.97	4.20	4.44	4.69
	Q20	3.94	4.15	4.41	4.65
	Q22	3.97	4.18	4.44	4.69

All values are rounded to two decimal places

Improvement suggestions

The efficiency scores of expectations and perceptions for the overall service quality are 1 and 0.77, respectively. This shows that the overall expectations of customers were not met by the hotel services. The target levels of perceptions from 29 service quality attributes that caused the hotel achieve their DPSQI were calculated by (8) and shown as $P'_{Q_i}(\text{DPSQI})\ (i = 1, \ldots, 29)$ in Table 5.

It is often difficult to eliminate all quality gaps in a short period of time. However, the information provided by the model could be used by the hotel management to improve their service quality in the long term by focusing on their weaknesses and inefficiencies.

Conclusion and future research directions

A key challenge for researchers is to accurately devise methods for measuring service quality gaps (Parasuraman et al. 1985). The hybrid DEA-SERVQUAL approach proposed in this study was effectively used to measure the service quality of a hotel in Tehran. Among the various methods of service quality evaluation, SERVQUAL has been widely used in different service industries. The SERVQUAL gap has been used to analyze the level of service quality items, dimensions, or the overall service quality in many studies. Equation (1) which was used to measure the overall service quality does not provide a clear insight into the level of customer perceived service quality. In addition, because of the public tendency to rate the expectation high, the perception scores are dominant contributors to the gap score (Babakus and Boller 1992). The approach proposed in this study addresses this limitation by producing a single measure (PSQI) as the efficiency of the perceptions.

Comparing this integrating measure with the perceived quality that is calculated using Eq. (1), the PSQI shows the level of service quality of the organization clearly and delineates the real distance of the offered service quality to the ideal level. In addition, a proposed NLP model based on the SBM, introduces the improvement guidelines in terms of the items and dimensions of quality to enhance service quality with regards to a set of quality attributes. The proposed method not only analyzes the strengths and weakness of the service organizations, but the integration of service quality and DEA can generate benchmarking guidelines for both perception and expectation of customers.

In this paper, DEA as a non-parametric approach is used to measure the efficiency of DMUs. Therefore, using DEA, the requirements imposed on the distributional properties of the data for conducting parametric statistical tests (e.g., *t* tests) do not need to be satisfied. Therefore, this method can be used in performance measurement problems with similar statistical limitations.

Furthermore, service quality should be measured periodically to make continuous improvement as a vital part of service management planning. Hence, the ability of assessing service quality as a single and accurate measure is necessary.

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