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A new decision-making tool: the service performance index

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Abstract *Measuring service performance in an appropriate way has received widespread attention due to the vital role customer service plays in gaining competitive advantages. Since service performance directly correlates with customer satisfaction, measuring service performance that attempts to assess validity is a concern for many firms. The new proposed index, the service performance index, will involve observing the number of customer complaints that the firm receives. Since sample data must be collected to calculate these indices, the results will be exposed to sampling errors. Taking sampling errors into account, the uniformly minimum variance unbiased (UMVU) estimator is used to develop a procedure in order to generate an index value that is more reliable.*

1. Introduction

Customer service involves implementing a set of activities and represents the output of a service system. The meaning of customer service varies from one firm to another. LaLonde and Zinszer (1976) pointed out that customer service could be viewed in several ways:

- as an activity;
- as an indication of performance levels; and
- as a philosophy of management.

LaLonde *et al.* (1988) defined customer service as: "... a process for providing significant value-added benefits to the supply chain in a cost-effective way". Customer service has received widespread attention over the years due to the demands of the global market. Price and quality are no longer enough to attract customers or maintain customer loyalty, instead, the key determining factor has been service. Customers will reward those companies who can provide or exceed their service expectations. Consequently, the level of service a firm provides has a tremendous impact on its market share and its profitability.

Since resources available in a firm are limited, full engagement of some activities will inevitably be at the cost of others. Therefore, the decision makers will need to understand issues such as what activities customers value, how satisfied customers are, and how customers respond to the different levels of service. Ideally, an explicit relationship, either a mathematical formulation or a descriptive model, between the level of service provided and the profits generated is of great help in decision making. The task of planning and

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controlling a service system can be greatly enhanced if decision makers know precisely how profits (or costs) will change with the variation of service level. However, since it is difficult to develop such a relationship in practice, one common way is to establish a desired level of customer service. Once that is established, the next step is to try to attain that level at the lowest cost to the firm.

To determine an appropriate level of customer service, a systematic procedure has to be developed for measuring performance. The benefit of carrying out such a procedure is to improve the quality of service by establishing control procedures to ensure the performance level does not fall below the desired level. Instead of conducting statistical analysis, the service performance index uses an explicit expression that measures the number of complaints occurred and the desired target set by the firm. Afterwards, a hypothesis-testing procedure is used to check whether the index meets the target. By applying the proposed methodology, a theoretical basis for measuring service performance would hopefully be established.

2. Service performance index

Substantial research has been dedicated to the analysis of service performance in applications such as quality management and logistics management. Major issues associated with the analysis of service performance include how the performance is defined, what methodologies are developed to measure the performance, and how the service elements are selected. When defining performance, the research methodology employed greatly differs (see for example Bowersox and Closs, 1996; Chow *et al.*, 1994; Lalonde and Zinszer, 1976; Marr, 1994 and Mentzer and Knoard, 1991). Methodologies and findings of the major studies relating to service performance conducted in the past are summarized in Tucker (1994). Numerous emerging approaches to measuring customer service extend to the use of data envelopment analysis (Charnes *et al.*, 1981; Clarke and Gourdin, 1991; and Kleinsorge *et al.*, 1991) and the Taguchi method (Holcomb, 1994 and Taguchi and Wu, 1980). Finally, to analyze service performance, it is important to select the proper set of elements so that customer responses can be closely monitored. To do so, one can consider the "representativeness" (Chow *et al.*, 1994) which means that the set of elements chosen will capture the dimensions of the performance.

Following the idea of representative service elements, it is assumed that there are total k service elements identified in a firm. For each service element i, $i = 1, 2, \ldots, k$, we measure its performance in terms of examining the degree of customer satisfaction which can be done by counting the number of customers who complain. Service performance alone has been put forward by many researchers as the best indicator of satisfaction (Liljander and Strandvik, 1997). Naturally, a number of factors contribute to customer satisfaction with the level of service received. Much of the literature on satisfaction focuses on the expectancy-disconfirmation paradigm as a means of identifying the process by which customers evaluate satisfaction. Recent models have extended to include effective dimensions and emotions (Oliver, 1993). To measure the degree of the customer satisfaction, there are two broad types of scales used in the literature, which are the single- and the multi-item scales. Many researchers have used simple single-item scales (generally having 2-9 points) to reflect "very satisfied" or "very dissatisfied" responses. Recognizing the shortcomings of using single-item scales, recent studies have mainly used multi-item scales. Here, customers are not just asked to give an overall evaluation of their satisfaction with the service but are also asked to rate the key components of the service process. With this methodology, several measures of satisfaction are obtained which can be combined through averaging or factor analysis into a single measure or index. For more details concerning question scales used for measuring customer satisfaction, see Danaher and Haddrell (1996).

In this study, it is not our primary objective to investigate factors such as how to measure the severity of the complaint. Nor do we try to categorize the nature of the complaints. Instead, our main objective is to establish an index that sufficiently captures the essence of measuring customer satisfaction based on mathematics because research on satisfaction has normally been very cognitive in nature (Liljander and Strandivk 1997). Moreover, Stauss and Neuhaus (1997) suggested that a customer score, using a satisfaction index, is closely connected with various emotional, cognitive, and intentional components. Therefore, the ratio of the number of customers with complaints to the total number of customers encountered in a given period is used to measure the degree of customer satisfaction. The approach has been characterized as "fraction nonconforming" (Montgomery, 1996) and widely used in applications such as observing the number of deliveries made by a supplier that are not on-time. In the paper, we use the term fraction and the definition is as follows:

$$\textit{fraction}\ (p) = \frac{\text{number of customers with complaints}}{\text{total number of customers encountered}}$$

Rather generic as it may appear to be, several researchers advocated a similar idea of using a single expression. For example, Hawes and Arndt (1982) suggested that a single global indicator of a customer's reaction to the service received is the most common measure of customer satisfaction. Yi (1990) also suggested that a single overall satisfaction measure was "reasonably valid".

By and large, p has characteristics similar to the defect rate in a manufacturing process and is classified as the type of "attributes". A Bernoulli distribution is commonly used to describe the situation of customer complaints. For example, assume that p is the fraction of a service element i, let random variable X equal 1 if the customer complains about service element i and 0 otherwise. Then random variable X conforms to a Bernoulli distribution with parameter p, the probability is represented by $Pr(\mathrm{X} = 1) = p$ and $\Pr(X = 0) = 1 - p$.

Because a smaller fraction represents a greater degree of customer satisfaction, the firm can set a ceiling level for each element i, i.e. the minimum service requirement. In general, one firm's service level differs from another because of various factors involved in setting the level. The definition of the service performance index of element i can be expressed as follows:

$$S_{pi} = \frac{P_{0i} - P_i}{P_{0i}}, \ i = 1, \ 2, \ \ldots, \ k, \tag{1}$$

where,

P_i is the fraction of service element i,

P_{0i} is the maximal allowable fraction of service element i.

The use of equation (1) is justified as follows. First, it is unit-less whose importance from a practical perspective has been pointed out in Kane (1986). Second, the calculation of the equation is very straightforward. Finally, it provides the insights into the relationship between the index value and the practical interpretation. For example, according to equation (1), it is in the firm's best interests to maximize the value of S_{pi}. The reasons are twofold. On the one hand, in the situation where $P_i > P_{0i}$, which means that the fraction of customer complaints is beyond the firm's acceptance and obviously not desirable, then S_{pi} is less than 0. On the other hand, for a fixed P_{0i} where $P_{0i} > P_i$, S_{pi} increases as P_i decreases. That is, given a P_{0i}, a larger S_{pi} (or a smaller P_i) indicates that the service quality of element i is better. In consequence, the use of S_{pi} plays an intuitive role in interpreting the excellence of service performance. The maximal value of S_{pi} happens to be 1, the most encouraging result where no single complaint takes place.

3. Estimation of performance indices

As usually done, we need to estimate S_{pi} in that their real values are generally unknown. Because the total number of customers encountered each day may differ, we use random variable X_{ijh} to represent the h-th customer in the j-th observed sample for service element i, where $i = 1, 2, \ldots, k$; $j = 1, 2, \ldots, m$; and $h = 1, 2, \ldots, n_j$. By this notation, let random variable X_{ijh} equal 1 if the h-th customer in the j-th observed sample for service element i complains and 0 otherwise. Apparently, random variable X_{ijh} conforms to a Bernoulli distribution with parameter p_i. Since p_i is also unknown, to estimate p_i, we denote the estimator of p_i by $\bar{p}_i = , \frac{D_i}{n}$ where $n = (\sum_{j=1}^{m} n_j)$ represents the total number of customers from m observed samples; D_i $(=\sum_{j=1}^{m} D_{ij})$ is the total number of customers with complaints from m observed samples for element i, D_{ij} $(=\sum_{h=1}^{n_j} X_{ijh})$ denotes the total number of customers with complaints in the m-th observed sample for element i, and $\hat{p}_{ij}$ $(= \frac{D_{ij}}{n_j})$ means the fraction of customers with complaints in the j-th sample for element i. Table I illustrates the use of data from m observed samples for element i.

Thus, the natural estimator of S_{pi} can be written as the following:

$$\hat{S}_{pi} = \frac{p_{0i} - \bar{p}_i}{p_{0i}}, \ i = 1, \ 2, \ldots, \ k. \tag{2}$$

Sample number	Sample size	Number of customers with complaints	Fraction of customers with complaints
1	n_1	D_{i1}	$\hat{p}_{i1} = \frac{D_{i1}}{n_1}$
2	n_2	D_{i2}	$\hat{p}_{i2} = \frac{D_{i2}}{n_2}$
.	.	.	.
.	.	.	.
j	nj	D_{ij}	$\hat{p}_{ij} = \frac{D_{ij}}{n_j}$
.	.	.	.
m	n_m	D_{im}	$\hat{p}_{im} = \frac{D_{im}}{n_m}$
Total	$n = \sum_{j=1}^{m} n_j$	$D_i = \sum_{j=1}^{m} D_{ij}$	$\bar{p}_i = \frac{D_i}{n}$

Table I.
m observed samples for element *i*

It is easy to show that $\bar{p}_i$ is an unbiased estimator of p_i. Therefore, since $E[\bar{p}_i] = p_i$ and depends only on the complete, sufficient statistic $\bar{p}_i$, it follows $\hat{S}_{pi}$ that is a *uniformly minimum variance unbiased* (UMVU) estimator of S_{pi}. The variance of the estimator for S_{pi} is as follows:

$$\text{Var }(\hat{S}_{pi}) = \frac{(1 - S_{pi})[1 - p_{0i}(1 - S_{pi})]}{np_{0i}}, \ i = 1, \ 2, \ \ldots, \ k. \qquad (3)$$

4. Procedure for testing hypothesis problem

Determining whether the service performance meets a preset target, say S, is an important task in practice. To resolve this problem, a hypothesis-testing problem as proposed by Kane (1986) is developed. Consider the following problem:

H_0: $S_{pi} \leq S$ (or the performance is not acceptable)

H_a: $S_{pi} > S$ (or the performance is acceptable)

The above hypothesis-testing problem suggests that the service performance meets the service target if $S_{pi} > S$, or fails when $S_{pi} \leq S$. Our intention is to try to reject H_0, demonstrating that the service performance is acceptable. Based on *central limit theorem*, we can calculate the rejection probability, or commonly called p-value, to make a decision. The p-value "is the probability that the test statistic will take on a value that is at least as extreme as the observed value of the statistic when the null hypothesis H_0 is true" (Montgomery, 1996). So, "a decision maker can draw a conclusion at any specified level of significance". Let the test statistic of S_{pi} be denoted as $\hat{S}_{pi}$ whose observed value equals to V_i, then

$$p\text{−value} = P(\hat{S}_{pi} \geq \ V_i | S_{pi} \leq S) = \text{P}\left(Z \geq \frac{\sqrt{np_{0i}}(V_i - S)}{\sqrt{(1 - S_{pi})[1 - p_{0i}(1 - S_{pi})]}}\right), \ (4)$$

where,

$$Z = \frac{\sqrt{np_{0i}}(\hat{S}_{pi} - S)}{\sqrt{(1 - S_{pi})[1 - p_{0i}(1 - S_{pi})]}}$$

According to the *central limit theorem,* variable Z is approximately normally distributed. It is worth noting that, in light of the equation (1), if the value of S equals 0, the performance at least meets the target. A larger S means that the firm establishes a higher target (i.e. fewer numbers of allowable complaints). For this reason, it is normally assumed that S equals to 0.

To determine whether the service performance meets the preset target, we first have to determine S, and choose the α-risk. Then, we calculate the estimated observed value of the index from the sample, that is, $\hat{S}_{pi} = Vi$. Finally, according to the equation (4), we find the p-value based on V_i, and sample size n to reach the conclusion. In management's perspective, however, the computational results are more valuable if they are organized in such a form that the decision-making process can be benefited. To serve this purpose, we initiate a table (Table II) with designated marks capable of visually indicating the status of the service performance. The complete testing procedure is stated as follows in steps:

The procedure:

(1) Determine the value of S (normally set to 0), and the α-risk (normally set to 0.01 or 0.05).

(2) Determine sample size n.

(3) Compute $\hat{S}_{pi}$ (assume the observed value to be V_i) based on the sample size n. Fill in Table II under the column $\hat{S}_{pi}$.

(4) Compute p-value based on V_i and the sample size n. Fill in Table II under the column p-value.

(5) Determine whether the performance target is satisfied by checking:

- If the p-value is less than α-risk, we conclude that the service performance meets the preset target.

Table II. Service performance indices

	$\hat{S}_{pi}$	p-value
Service element 1	$\hat{S}_{p1} = V_1$	p_1
Service element 2	$\hat{S}_{p2} = V_2$	p_2^{*}
Service element 3	$\hat{S}_{p3} = V_3$	p_3^{***}
.	.	.
.	.	.
.	.	.
Service element k	$\hat{S}_{pk} = V_k$	p_k

- Otherwise, we do not have sufficient information to conclude that the process meets the preset target.

Take Table II to illustrate its application. The value p_2 is marked with an "*", which indicates that the service performance of element 2 at least meets the preset target, while element 1 does not because of lacking an "*". The markings can be represented in more detail for practical use. For instance, the firm can further classify the levels of performance into three categories by checking different sets of p-values: excellent (p-value ≤ 0.01), moderate ($0.01 < p$-value ≤ 0.05), and poor (p-value > 0.05). In an excellent case such as p_3, a popular way is to associate it with "***" to highlight it as an excellent outcome.

5. Conclusion

Achieving a high quality of customer service has become increasingly critical in the service industry and has been the focus of study by the practitioners. From a practical perspective, how to measure service performance suitably is important for a firm to determine whether the desired target is achieved. In this paper, we propose a methodology for measuring service performance. The methodology uses a performance index that is easy to apply, and gives an insight into the practical application. Based on the proposed performance index, we also develop a step-by-step procedure to deal with the hypothesis-testing problem.

Several limitations should be mentioned in this paper, however. First, the index is simply based on the number of customers with complaints in ratio to the total number of customers encountered. The underlying assumption is that every dissatisfied customer will register a complaint. This may not be an accurate assumption given that many people do not always voice their displeasures with service, but merely choose not to return to the business for further service. Further, as we pointed out in Section 2, more efforts are required to develop a model that takes measuring the severity of the complaint into account. To do so, one way is to consider adding information when customers register complaints. For example, a complaint may be a minor complaint, registered by one individual compared to several individuals complaining about a major service problem. From a manager's perspective, it is more important to know the seriousness and repetitiveness of the complaints rather than the mere number of complaints registered compared to the total number of customers.

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