An Application of Total Quality Management Efficiency Model in the Korean Distribution Industry

Hanjoo Yoo[1†], Jong-Woo Park[1] and Gwangsuk Song[1]

[1]Division of Business Administration, Soongsil University
511, Sangdo-Dong, Dongjak-Gu, Seoul, 156-743, Korea
E-mail: hyoo@ssu.ac.kr

Abstract

The purpose of this study is to analyze the efficiency of the service quality activity itself by using the DEA Model, in contrast to previous quality evaluation methods, as an attempt to evaluate the service quality activities of the distribution industry. Furthermore, by complementing the shortfalls of the weighted value of the DEA Model, it recommends a DEA/PS Model that is appropriate in the evaluation of service quality activities. Based on this model, the study proposes the SQAE Model, an evaluation tool to complement the traditional measuring method. According to the results of the analysis of 18 sample distribution businesses, there was a discrepancy by business in the results of the Traditional Scoring System and the Evaluation Measuring System. Therefore, it is most desirable to not only be active in service quality activities but also increase efficiency at the same time.

Key Words: TSS, EMS, DEA Model, Efficiency Model

1. Introduction

On the characteristics of the service organization, Juran (2002) points out that in contrast to the manufacturing sector, there is a lack of quality specialists in the service industry, quality management is not a daily activity, there is no high-level management in charge of quality management and no cooperative system exists between departments for quality improvement[5]. In addition, the efficiency assessment itself is difficult in this industry because activities, including customer services, are organically interlinked. This, among others, lowers the efficiency and quality level of the service organization compared to that of the manufacturing industry. In terms of customer-oriented product design, however, the efficiency of a service company can be measured by customer service activities. In other words, the efficiency of service quality management can be assessed by taking the company's service management activities as the input and customer satisfaction, willingness to re-use or recommend

† Corresponding Author

the service as the output. The result would signify the capability of the organization to maximize output with minimum input.

In order to analyze the efficiency of the service organization, the various factors involved in the production process must be identified as either input or output factors, but there is no significant criterion in this task. Provided, if it is desirable for a certain factor to be relatively less in quantity in producing an equal level of output, then it can be regarded as an "input factor", and vice versa-if it is desirable for a certain factor to be relatively more in quantity when maintaining an equal level of input, it can be regarded as an "output factor". [6] Therefore, in this paper, service quality factors have been defined as the "input factor" in analyzing the efficiency of customer services in the domestic distribution industry, and the overall satisfaction, and willingness to re-use and recommend a service as the "output factor" in analyzing the efficiency of the distribution industry.

Service quality assessment can provide an important perspective in the strategic decision-making of a business in today's management environment of increasingly intensified competition. It is also valuable information since it highlights the efficient companies in the same industry, the best practices in the market. In particular, for a service company to generally enhance the level of customer services regardless of its capacity could prove to be counter-effective, not only in terms of business efficiency, but also, strategically. Furthermore, the domestic distribution industry is facing the opening of the market and increased price competition, not to mention competition in services. Taking this into consideration, the assessment of the efficiency in the service industry is an imperative study that must be undertaken and the results will be valuable working-level information. The continuous growth in this sector has been accompanied by numerous studies on service quality, most of which have a tendency of emphasizing the study of the dynamic relationship between customer satisfaction and customer retention, and service mechanism by using SERVQUAL or SERVPERF, prime assessment tools in service quality. In particular, the assessment of productivity or efficiency in the service industry is not easy due to the number of intangible input factors, and most of such assessments are based on physical factors. The DEA (Data Envelopment Analysis) technique, however, is an adequate method to analyze service industry efficiency because of the following three reasons[6, 7].

First, efficiency based on the non-parametric approach method can be derived solely from the quantity observation data of input/output factors.

Second, in contrast to the efficiency analysis methodology that uses the parametric methodology, DEA uses the non-parametric methodology which is not based on functional assumptions.

Third, DEA analysis results not only enable the analysis of the efficiency level of the relevant company, but also recognize best practice firms that can become a model for inefficient companies seeking to transform into efficient ones.

In assessing the quality level of a service organization, the most popular traditional evaluation method is the summation of the quality level experienced by customers. The representative evaluation models include measurement tools such as KS-SQI, NCSI and KSQI, and their contribution to the qualitative advancement of the Korean service industry has been quite remarkable. However, they have not been able to provide information on the efficient operation of input/output resources by corporate organization units.

In this context, this study strives to analyze the efficiency of service quality activities of four business categories (department store, discount store, home shopping, and on-line shopping mall) in the Korean distribution industry, and compare the Traditional Scoring System based on the weighted sum and the DEA Efficiency Measuring System. Based on this, the main goal of this study is to suggest management implications on the distribution industry.

2. Literature Review

2.1 CCR/BCC Model

The efficiency of a certain company's activities can be determined by comparing its results with that of a selected comparative criterion. In other words, whether relatively more resources were used in producing the same amount of output vis-à-vis the comparative criterion or whether relatively less output was produced with an identical amount of input can be measuring sticks in determining the level of efficiency. In this case, the comparative criterion could be a viable result or a company with the best performance in the same industry. A unique feature of the DEA efficiency analysis is that it is based on linear programming and does not use a general functional assumption that estimates the parameter. It is a non-parametric approach that measures the efficiency between the relevant subjects by comparing the empirical efficiency frontiers based on input/output data. This method stems from studies by Charnes, Cooper and Rhode (1978, referred hereinafter as "CCR"). The CCR Model utilizes the technique of measuring the relative efficiency of single input/output models, and applies and optimizes it to multiple input/output models[2, 3]. In particular, not only can it be applied efficiently to measuring the performance of units using multiple input factors to produce multiple outputs, but it is also known to be effective in cases where the input-output transformation is unknown.

A brief explanation of the CCR Model is as follows: Let us assume that there are K number of companies in the analysis sample, and each company uses m-type outputs and n-type inputs. If the input and output of Company $kX_k = (x_k^1,\ x_k^2,\ \cdots\ x_k^n)$ and $Y_k = (y_k^1,\ y_k^2,\ \cdots\ y_k^h)$ is, the efficiency of Company k can be calculated by linear programming, as in the following Formula (1):

$$\text{Maximize} \qquad h_k = \frac{u^T Y_k}{v^T X_k} \tag{1}$$

$$\text{s} \cdot t \qquad h_i = \frac{u^T Y_i}{v^T X_i} \leq 1, \qquad i = 1, \cdots, n$$

$$u^T \geq 0 \quad \text{and} \quad v^T \geq 0$$

u^T and v^T in the above formula are the virtual multipliers allocated to the input and output factors, and through these multipliers, multiple outputs and inputs are defined as single scalar values. Therefore, as demonstrated in the objective function, the efficiency of Company k is the ratio of the virtual input and virtual output. Virtual multipliers can be derived under the conditions that satisfy the assumption that all companies have an efficiency smaller than 1, so in the end, it is determined after using all observatory information. If the above formula is the primal of linear programming, it can derive the following Formula (2), the dual model. These two models can provide perfectly identical information due to complementarily slackness.

$$\text{Maximize} \qquad v^T X_k \tag{2}$$

$$\text{s} \cdot t \qquad u^T Y_k = 1$$

$$u^T Y_i - u^T X_i \leq 0, \; i = 1, \cdots, n$$

$$u^T \geq 0 \quad \text{and} \quad v^T \geq 0$$

The above formula is different from the primal problem as it measures efficiency by building a production frontier composed of input/output factors and calculates the distance between the observational point and the production frontier.

u^T and v^T are input factor multipliers. In case of the CCR Model, the sum of the multipliers is always equal to or less than 1, and when the multiplier is '1', it is judged to be an efficient DMU. In other words, in the case of an input-oriented model, the sum of multipliers is always less than 1 in an inefficient DMU. On the other hand, in the BCC Model, the limiting condition is that the sum of multipliers is always 1.

Whereas the CCR Model demonstrates the overall technical efficiency (TE), the sum of technical efficiency and scale efficiency (allocative efficiency), the BCC Model shows pure technical efficiency(PTE). In particular, the BCC Model derives pure scale efficiency by dividing the CCR Model's overall TE (technical efficiency + scale efficiency) by the BCC Model's technical efficiency. This is the reason behind the multiplier limiting condition in the BCC Model.

2.2 DEA/PS Model (DEA Preference Structure Model)

In general, the input-oriented DEA model tries to reduce the input amount while maintaining the current output level, whereas the output-oriented DEA model focuses on increasing the output while maintaining the current input level. The main feature of these models is that it only takes into account the relative ratio between the actual input and output volumes, and not the slack of the ideal target of the actual input. In addition, the CCR Model, which is the basic DEA model, takes the relative input and output or DMUs being measured into account, and the virtual multipliers u^T and v^T of input resources change according to the repetitive calculation of the LP Model. The ideal target derived from such an analysis process is calculated into the relative size of the input or output and the slack is measured by the relative input/output.

The benchmarking information presented to an inefficient DMU in the DEA Model analysis is a best practice case referred to by inefficient DMUs when seeking to transform into efficient DMUs. It, however, generates idealistic information that ignores features unique to the inefficient DMU[10, 11]. To resolve this issue, the DEA/PS Model (DEA Preference Structure Model), which directly inputs the multipliers of input or output resources, was proposed. This method of inputting multipliers is also the method that determines the order of management of input or output resources.

The DEA/PS Model inputs certain multipliers into input or output resources and does not apply the relative multiplier which is used to derive the answer to the LP Model that is determined by the relative size of the input or output resource. It inputs the multiplier according to a specialist's opinion or analyst to provide the ideal target under the assumption that the slack of the currently inputted resource is '0'. The input-oriented DEA/PS Model used in this study is as shown in Formula (3):

$$\text{m in} \quad \left(\frac{\sum_{i=1}^{m} A_i \theta_i}{\sum_{i=1}^{m} A_i} - \epsilon \sum_{r=1}^{s} s_r^+ \right) \tag{3}$$

subject to

$$\sum_{j=1}^{n} \lambda_j x_{ij} = \theta_i x_{io} \qquad i = 1, 2, \cdots, m$$

$$\sum_{j=1}^{n} \lambda_j y_{ij} - s_r^+ = y_{ro} \qquad r = 1, 2, \cdots, s$$

$$\lambda_j \geq 0$$

$$\text{target} \quad \begin{cases} x_{io} = \theta_i x_{io} \\ \hat{y} = y_{ro} + s_r^{+*} \end{cases}$$

Zhu(2003), *Quantitative Models for Performance Evaluation and Benchmarking*, p. 94.

The multipliers used in the study will be applied to the DEA/PS Model by using the multipliers calculated according to the relativity analysis of the input and output resources.

3. Research Design

This paper evaluates the service activities of domestic distribution businesses by using the Traditional Scoring System (TSS), an evaluation method based on weighted average, and the Efficiency Measuring System (EMS), the DEA-based efficiency evaluation method. The objective of the study is to propose a way to enhance the competitiveness of Korean distribution businesses, and present the Service Efficiency Index as a complementary index to the TSS. A total of 18 businesses in the domestic distribution industry were subject to analysis. They were companies evaluated by the Korean Standards Association for their service quality in 2006. The rationale behind the selection of the subjects was that they are leading companies in each of the four distribution sectors, and had the potential of becoming the guidelines of the industry. Upon the results of this analysis, the Korean distribution industry has been categorized into four different sectors, and this study strives to recommend measures to improve the service quality of each sector.

Table 1. Factors that compose KS-SQI

Service Level	Description
Primary Needs Fulfillment	Satisfaction of the primary needs of customers through service
Unexpected Benefits	Offer differentiated benefits and additional services to customer
Reliability	Customer reliability towards service providers, sincerity and integrity, and the necessary skills and knowledge to operate a service
Individual Empathy	Kind and polite manner towards customers courteous, respectful and polite manner
Positive Assistance	The will to swiftly provide services in response to customer need
Accessibility	Convenience of service provision hours and place
Physical Evidence Media Tangibles	External clue to service evaluation

Table 1 illustrates the factors that compose KS-SQI, a Traditional Scoring System, and Figure 1 demonstrates the research procedures in conducting this study.

In Phase 3, the input and output factors finally selected were used to analyze the service efficiency of 18 major businesses in the four distribution sectors in Korea. In particular, the analysis was compared with the input-oriented CCR, BCC and DEA/PS Models to present the characteristics of the DEA/PS Model.

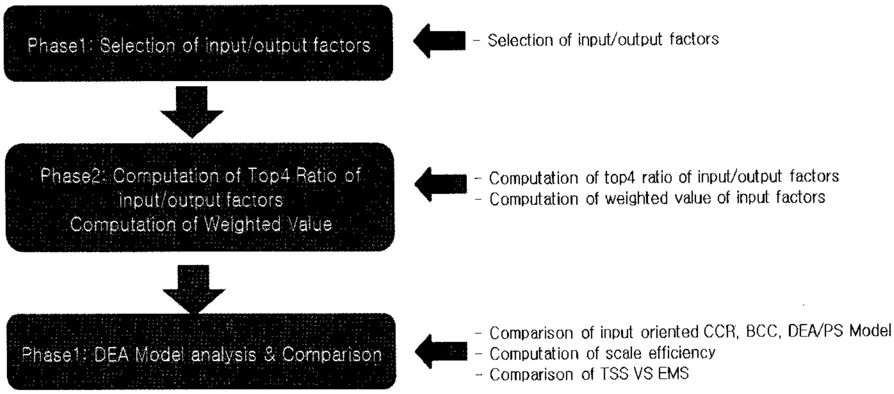

Figure 1. Research Procedures

Table 2 and Table 3 are the weighted value of the input factors used in the final input/ output value and analysis.

Table 2. Final input/output value

Classification Types	Input factors								Output factors		
	DMUs	IN_1	IN_2	IN_3	IN_4	IN_5	IN_6	IN_7	OUT_1	OUT_2	OUT_3
Department Store	F1	91.97	91.64	92.98	90.97	86.62	93.31	94.65	88.63	77.93	91.97
	F2	93.36	90.03	95.35	91.36	89.04	93.36	94.35	90.37	82.39	92.69
	F3	92.67	85.00	93.67	92.33	89.67	92.33	94.67	91.00	80.33	91.00
Discount Store	F4	94.33	93.67	96.00	91.33	94.00	93.67	94.67	90.67	92.67	86.33
	F5	89.67	89.33	94.00	89.00	91.33	95.67	91.67	89.33	90.00	82.00
	F6	91.67	79.67	91.00	88.67	88.33	89.33	88.67	87.33	85.00	75.00
	F7	83.33	72.67	83.00	80.33	77.33	86.33	82.67	77.67	72.67	63.67
	F8	82.00	78.00	87.67	83.33	84.67	88.33	84.67	79.33	79.00	66.00
Online shop-ping mall	F9	96.33	94.00	95.67	92.67	93.33	93.00	93.67	93.67	93.33	82.00
	F10	90.00	86.33	89.33	87.67	89.33	89.33	89.00	85.00	81.33	78.67
	F11	94.00	90.00	91.67	87.00	89.67	89.33	91.00	85.67	87.67	80.67
	F12	89.33	85.67	88.67	83.33	84.33	85.00	87.00	82.67	83.33	78.67
	F13	95.00	95.33	95.33	95.00	95.00	95.33	94.33	92.67	93.33	86.67
	F14	92.67	91.33	93.67	90.00	91.33	91.33	92.67	90.00	87.00	80.33
Home Shopping	F15	92.33	89.33	94.00	91.00	89.33	91.00	93.33	87.33	87.67	77.33
	F16	90.00	90.00	93.33	91.33	88.67	93.33	90.33	87.33	85.67	77.00
	F17	92.33	90.00	94.67	92.33	91.33	91.67	92.33	88.67	84.00	77.00
	F18	91.00	90.67	94.67	92.00	92.00	92.00	92.67	88.33	88.33	82.33

Table 3. Weighted value of the input factors

Services	Department Store	Discount Store	Online Shopping mall	Home Shopping	Final Weighted Value
IN_1 (Primary Needs Fulfillment)	0.139	0.137	0.135	0.140	0.138
IN_2 (Unexpected Benefits)	0.127	0.134	0.136	0.131	0.132
IN_3 (Reliability)	0.155	0.148	0.151	0.159	0.153
IN_4 (Individual Empathy)	0.141	0.136	0.129	0.138	0.136
IN_5 (Positive Assistance)	0.145	0.145	0.146	0.149	0.146
IN_6 (Accessibility)	0.132	0.145	0.142	0.139	0.139
IN_7(Physical Evidence)	0.161	0.156	0.161	0.145	0.156

4. Analysis Results

The study conducted a comparison on the analysis results of the CCR, BCC and DEA/PS Models in order to analyze the efficiency of service quality activities of 18 businesses in four distribution sectors in Korea.

Table 4. Analysis results of the three models

Type	DMUs	CCR	BCC	DEA/PS	Scale Efficiency
Department Store	F1	1.0000	1.0000	1.0000	1.0000
	F2	1.0000	1.0000	1.0000	1.0000
	F3	1.0000	1.0000	1.0000	1.0000
Discount Store	F4	1.0000	1.0000	1.0000	1.0000
	F5	1.0000	1.0000	0.9965	0.9965
	F6	1.0000	1.0000	0.9953	0.9953
	F7	1.0000	1.0000	0.9670	0.9670
	F8	0.9865	1.0000	0.9480	0.9487
Online Shopping mall	F9	1.0000	1.0000	1.0000	1.0000
	F10	0.9752	1.0000	0.9647	0.9819
	F11	0.9932	1.0000	0.9825	0.9903
	F12	1.0000	1.0000	0.9893	0.9893
	F13	1.0000	1.0000	1.0000	1.0000
	F14	0.9937	1.0000	0.9842	0.9961
Home Shopping	F15	0.9843	0.9913	0.9662	0.9865
	F16	0.9882	0.9948	0.9645	0.9891
	F17	0.9801	0.9909	0.9669	0.9957
	F18	0.9916	1.0000	0.9797	0.9951
	Efficient DMUs	10	15	6	6

According to the results, in case of the CCR Model, there were ten businesses out of a total 18 DMUs that operated efficient services: three department stores, four discount stores, and three online shopping malls. In case of the BCC Model analysis, only three home-shopping businesses, out of the total, were inefficient, and 15 businesses were efficient. In contrast, the DEA/PS Model showed that six businesses (three department stores, one discount store, and two online shopping malls) were efficient. The analysis results of the three models are as shown in Table 4.

According to the results, six DMUs out of the total 18 were found to be effective, proving that the results were more stable than that of the CCR and BCC Models. Also, in order to discern whether the efficiency evaluation of the four distribution sectors was computed by scale efficiency, the CCR DEA/PS Model was divided by the efficiency value of the BCC DEA/PS Model to calculate pure scale efficiency. The following Table 5 and Figure 2 are the analysis results of TSS and EMS:

Table 5. Analysis results of TSS and EMS

No. of Sample Business	TSS score	EMS score	No. of Sample Business	TSS score	EMS score
1	71.90	1.00	10	69.80	0.96
2	73.00	1.00	11	71.90	0.98
3	73.40	1.00	12	68.90	0.99
4	74.50	1.00	13	74.00	1.00
5	71.80	1.00	14	72.40	0.98
6	69.20	1.00	15	73.00	0.97
7	66.00	0.97	16	72.20	0.96
8	66.50	0.95	17	72.70	0.97
9	73.20	1.00	18	72.80	0.98

Note: TSS VS EMS correlation, 0.534, $p < 0.05$.

According to the results of Table 5, Businesses 4, 13, 3 9, 15, 2, and 18 that were among the top in the Traditional Scoring System were all found to be effective with the exception of Businesses 15 and 18. Businesses 15 and 18 were making great efforts in service quality activities but their efforts were not leading to customer satisfaction, re-purchase, and recommendation. In other words, the output was dramatically low compared to the amount of input resources. However, in case of Businesses 6 and 1, which were evaluated as 'low efficiency' in the Traditional Scoring System, were found to be efficient in the Efficiency Measuring System (EMS).

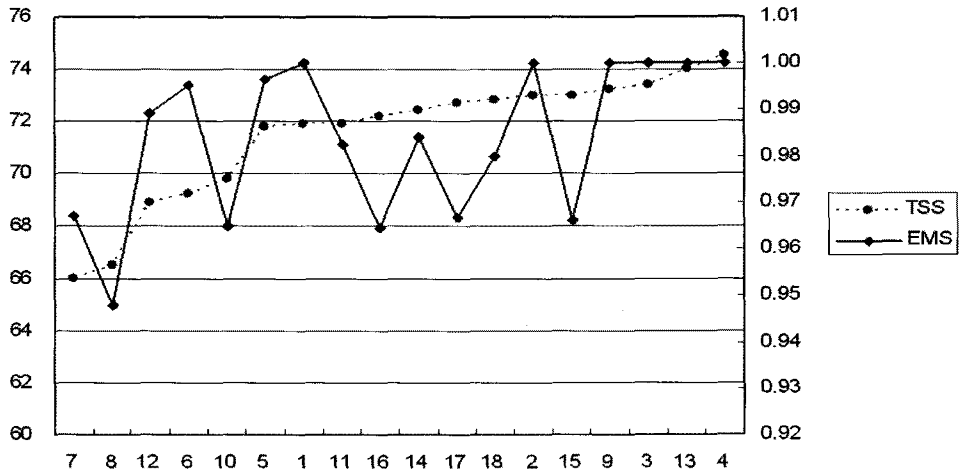

Figure 2. Analysis results of TSS and EMS

Figure 3 is the Service Quality Activities Evaluation Model (SQAE Model) that takes into account both the Traditional Scoring System and the Evaluation Measuring System based on Table 5 and Figure 2.

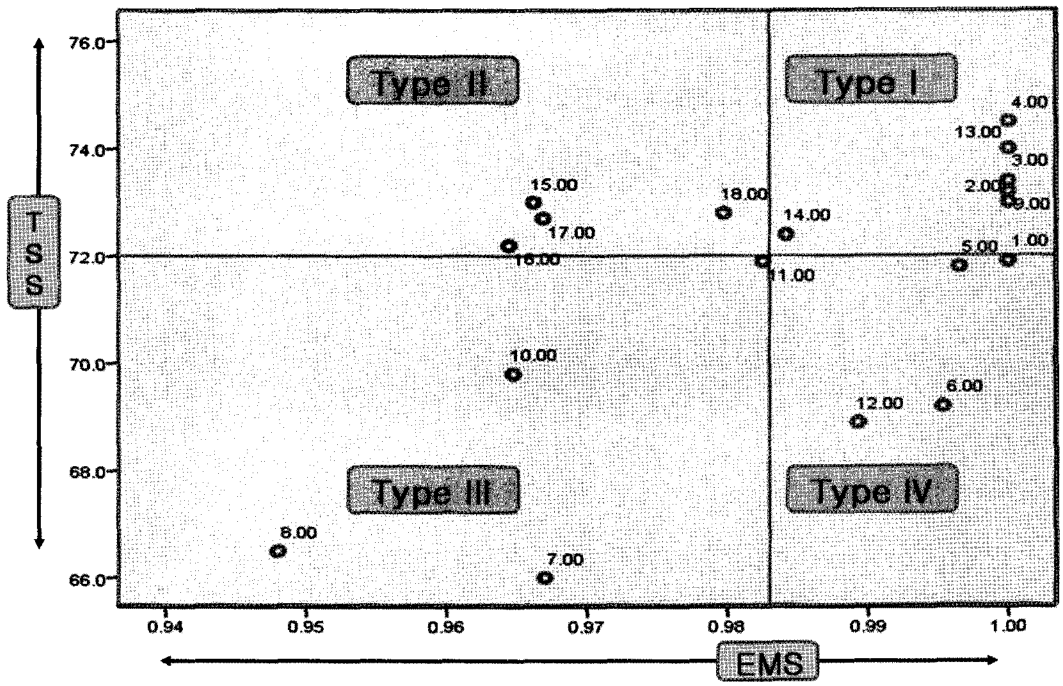

Figure 3. Service Quality Activities Evaluation Model

According to the Service Quality Activities Evaluation Model in Figure 3, the organization responsible for service quality can be categorized into the following four types, and the characteristics and measures to achieve service quality are as follows:

- Type Ⅰ: Sample businesses located in the first quadrant have both high weighted sum grades and high efficiency. These organizations should maintain the status quo, but must keep in mind that if they increase inputs but fail to efficiently utilize them, they are in danger of becoming a Type II business.
- Type Ⅱ: Sample businesses located in the second quadrant have high weighted sum grades but low efficiency. These organizations have many inefficient factors in their investments in improving service quality and must reduce them in order to move up to a Type I business.
- Type Ⅲ: Sample businesses located in the third quadrant have both low weighted sum grades and low efficiency. These organizations are low in efficiency in their service quality activities, and therefore, must first strive to raise efficiency and become a Type IV business. Businesses in the third quadrant must first conduct internal activities based on an efficient allocation of input resources.
- Type Ⅳ: Sample businesses located in the fourth quadrant have low weighted sum grades but high efficiency. Although these organizations are making efficient investments in service quality, they have low weighted sum grades, which signify that their overall performance in service quality activities is poor. From a long-term perspective, they must increase investments in order to enter the Type I business group.

5. Conclusion and Recommendation

According to the results of the analysis of 18 sample distribution businesses, there was a discrepancy by business in the results of the Traditional Scoring System and the Evaluation Measuring System. In other words, a high weighted sum does not always signify high efficiency. It goes without saying that the most critical issue in business management is the maximization of efficiency and effectiveness using limited resources. Among the businesses subject to evaluation, those that recorded high weighted sums were either awarded the No. 1 Service Award or received Service Accreditation. Those with low efficiency records must conduct systematic analysis and come up with measures to improve efficiency. Having a high weighted sum means that a lot of effort is going into service quality activities, but low efficiency means that regardless of the scale or efforts devoted to service quality, the amount of physical and non-physical resources inputted have not been used effectively.

Therefore, it is most desirable to not only be active in service quality activities but also increase efficiency at the same time. In other words, such efficiency analysis is not only complementary to a complete evaluation of service quality performance, but also an essential barometer.

Reference

1. Banker, D. R., Charnes, A., and Cooper, W. W.(1984), "Some models for estimating technical and scale inefficiencies in data envelopment analysis," *Management Science*, Vol. 30, No. 9.
2. Charnes, A., Cooper, W. W., and Rhodes, E.(1978), "Measuring the Efficiency of Decision Marking Units," *European Journal of Operational Research*, Vol. 2, No. 6, pp. 429-444.
3. Farrell, M. J.(1957), "The Measurement of Productive Efficiency," *Journal of Royal of Statistical Society*, Vol. 120, No. 3, pp. 253-290.
4. Jamieson, L. F. and Bass, F. M.(1989), "Adjusting Stated Intention Measures to Predict Trail Purchase of New Products: A Comparison of Models and Methods," *Journal of Marketing Research*, Vol. 26, pp. 336-45.
5. Juran, J. M.(2002), *Quality Control in Service Industries*, McGraw-Hill.
6. Lee J. D. and Kim, T. Y.(1997), "Measuring Network Effect in Energy Distribution Industry: With Policy Implications for Industrywide Regulation," *18th Annual North American Conference,* USAEE/IAEE, San Francisco.
7. Lewin, Y. A. and Knox Lovell, C. A. K.(1995), "Productivity analysis: Parametric and non- parametric applications," *European Journal of Operational Research*, Vol. 80, p. 451.
8. Mittal, V. and Kamakura, W. A.(2001), "Satisfaction, Repurchase Intent, and Repurchase Behavior: Investigating the Moderating Effect of Customer Characteristics," *Journal of Marketing Research*, Vol. 38, pp. 131-142.
9. Morwitz, V. G. and Schmittlein, D.(1992) "Using Segmentation to Improve Sales Forecasts Based on Purchasing Intent: Which "Intenders" actually Buy?," *Journal of Marketing Research*, Vol. 24, No. 4, pp. 391-405.
10. Zhu, J.(1996), "Data Envelopment analysis with preference structure," *Journal of Operation Research Society*, No. 47, pp. 136-150.
11. Zhu, J.(2003), *Quantitative Models for Performance Evaluation and Benchmarking*, kluwer Academic Publishers.