▩연구논문

A comparison of the traditional scoring system with the efficiency measuring system for evaluating the TQM activities

Hanjoo Yoo
Dept. of Business Administration, Sahmyook University, Korea
Jeong-Dong Lee
Techno-Economics and Policy Program, College of Engineering, Seoul National University, Korea

Abstract

In this paper, we analyzed two methodologies to evaluate the total quality management activities comparatively. One of them is the traditional scoring system (TSS) by analytic hierarchy process (AHP) and the other is the efficiency measuring system (EMS) by data envelop analysis (DEA). It is demonstrated that the index by TSS and the efficiency index by EMS are not correlated. Also, the efficiency index by EMS in terms of company characteristics such as the size of company and ISO certifications is different from the index by TSS. The result implies that to evaluate the quality activities by EMS is needed as a supplementary methodology.

1. Introduction

To measure the quality activities is the most fundamental and critical process as one of the PDCA cycle. The quality award criteria such as Malcolm Baldrige National Quality Award and Deming Award can be applied to the guideline for evaluating quality activities. We can identify several important factors for TQM by referring quality award criteria, but they don't suggest how efficiently implement TQM.

Empirical research has been done extensively to evaluate the performance of total quality management, as quality was regarded as an important strategic factor. Saraph, Benson, and Schroeder[6] interviewed 162 corporate managers and executives responsible for the quality management, and classified the critical success factors for TQM by factor analysis. Benson, Saraph, and Schroeder[2] showed that the organizational context affects manager's perception about the difference between ideal quality management and actual quality management. Adam [1] presented the two approaches to enhance the operating performance; the quality improvement approach and productivity improvement approach. He showed the relationship between a quality improvement approach and operating or financial performance empirically.

Despite the large body of empirical research about TQM, most of the studies has tended to identify the critical success factors[5]. However, there have been few studies in which the efficiency analysis of TQM activities is done with the concept of input and output factors.

In this paper, we analyzed two methodologies to evaluate the TQM activities comparatively. One of them is the traditional scoring system (TSS) by analytic hierarchy process (AHP). AHP is based on the hierarchical structure of several factors and it is the popular decision making tool in which the weight of each factor is calculated by the pair comparison method[6]. It has received widespread attention and has been applied to problems as diverse as decision analysis, forecasting, strategy formulation, and prediction of voting behavior[9]. Thus TSS means the evaluation system where the performance of TQM is evaluated by the weighted sum of critical success factors[4]. Several quality award system are typical examples of TSS.

The other is the efficiency measuring system (EMS) by data envelop analysis (DEA). DEA is a linear programming technique for the construction of a non-parametric, piece-wise linear convex hull to the observed set of input and output data; see, for example, Charnes et. al.[3] for a discussion of the methodology. Since the path-breaking paper of Charnes, Cooper, and Rhodes[3], there has been numerous applications in the field of efficiency measurement. Excellent review of the development of DEA and about the state-of-art can be found in Seiford[8]. DEA outperformed other alternative methods to measure the efficiency especially when there are not definite physical units and/or market prices for the inputs and outputs. Therefore, DEA can be applied to evaluate the TQM activities, in which critical factors are not marketable. We named the evaluation system by DEA as EMS.

It is necessary to evaluate TQM activities by EMS, because it is undesirable if TQM activities is inefficient even though TSS is high.

The objective of this paper is to compare TSS and EMS, to analyze the index by TSS and the efficiency index by EMS in terms of company characteristics such as the size of company and ISO certifications, and to suggest EMS by DEA as a supplementary methodology to evaluate the performance of TQM.

To achieve the objective, the sample of 101 Korean manufacturing companies were selected, and 47 companies were visited and well-structured questionnaires were mailed to the rest of them.

This paper is organized in four sections. The data collection process for this study and the evaluation processes by TSS and EMS are presented in the next section. In the third section, the comparative results by TSS and EMS and their correlation analysis are presented. Finally, we present a summary and the implications of this study.

2. Data collection and the evaluation processes by TSS and EMS

Survey questionnaires were mailed to a target sample of 540 manufacturing companies in Korea. These companies were selected from a directory provided by KSA (Korea Standard Association). Both primary and followup mailings were carried out. In order to supplement the results from the questionnaires, structured interviews were held with quality managers.

Questionnaire data collected by mail cover 101 different companies. The selection of critical success factors was based on literature reviews, and a content analysis was performed through several meetings by expert group.

In this article, as explained earlier, the relative importance weights on the critical success factors of TQM were calculated by following procedure. Questionnaires for AHP were mailed to the quality expert group which consists of 23 quality managers and professors. Collected data was processed by the computer program for AHP and the relative importance weights on the critical success factors were obtained as shown in <Table 1>. In Table 1, the values in parenthesis of second-level critical success factors can be calculated by multiplying the relative importance weights of first-level critical success factors by those of second-level critical success factors.

<Table 1> shows the most important factor is new product development (16.21%), subsequently, quality performance (15.95%), customer satisfaction management (14.76%), 'leadership (11.15%), and human resources management

(10.75%). On the other hand, environmental and safety management (5.15%) and information analysis (3.79%) have low weights relatively. They show the difference among critical success factors is recognized as significant.

The consistency ratio was 0.022, so the reliability of weights in <Table 1> is said to be high.

< Table 1 > Relative importance weights on the critical success factors of TQM in Korean companies

PRIMARY CRITICAL SUCCESS FACTORS (WEIGHT)	SECONDARY CRITICAL SUCCESS FACTORS	WEIGHT FOR SECONDARY FACTORS
Leadership and Organization for Quality (0.1115)	① Leadership of Top Management	0.537(0.0599)
	② Management for Quality	0.269(0.0230)
	③ Social Responsibility	0.194(0.0216)
Strategic Quality Planning (0.0630)	① Long and Short-Term Quality Policy	0.151(0.0095)
	② Quality Policy Deployment	0.319(0.0201)
	③ Review of Policy Output	0.530(0.0334)
Information Analysis (0.0379)	① Establishment of Information System	0.199(0.0075)
	② Comparative Analysis and Benchmarking	0.573(0.0217)
	③ Implementation of Computer System	0.228(0.0086)
New Product Development (0.1621)	① Product Quality Design	0.294(0.0477)
	② Technology for New Product Development	0.706(0.1144)
Process Management (0.0915)	① Quality Assurance System	0.386(0.0353)
	② Purchasing and Outsourcing Management	0.141(0.0129)
	③ Production Management	0.192(0.0176)
	④ Facilities Management	0.144(0.0132)
	⑤ Quality Assessment	0.137(0.0125)
Human Resources Management (0.1075)	① Human Resources Planning	0.198(0.0213)
	② Education and Training	0.520(0.0559)
	③ Employee Welfare and Incentives	0.282(0.0303)
Organizational Involvement (0.0677)	① Team Activities	0.273(0.0185)
	② Suggestion Activities	0.386(0.0261)
	③ Quality Circle	0.341(0.0231)
Environmental and Safety Management (0.0515)	① Environmental Management	0.545(0.0281)
	② Safety Management	0.455(0.0234)
Customer Satisfaction Management (0.1476)	① Customer Needs Survey	0.562(0.0829)
	② Customer Management	0.221(0.0326)
	③ Customer Satisfaction Survey	0.217(0.0320)
Quality Performance (0.1595)	① Quality Improvement Level Compared to Domestic Companies	0.385(0.0614)
	② Quality Improvement Level Compared to Foreign Companies	0.615(0.0981)

The DEA model uses a mathematical programming technique to estimate the efficient frontier. It is an external process which analyze each company separately and measures its relative efficiency based on the performance of best-practiced company. A DEA based efficiency model can also accommodate a variable that is neither an economic resource nor a product[5]. DEA provides solutions using standard techniques of linear programming and thus provides the benefits of computational efficiency, dual variables and clear interpretations. The empirical orientation and absence of a priori assumptions have made it possible to measure efficiency from direct efficient frontier estimation in non-profit and regulated sectors as well as in profit-maximizing organizations. The applicability of DEA in OR/MS (Operations Research/Management Science) can be easily confirmed in the bibliography prepared by Seiford[8] which presents more than 600 DEA contributions in the past 15 years. The DEA model is particularly plausible in the situation where there are not definite physical units and/or well defined market prices of inputs and outputs. Thus, for the data generated through AHP reflecting both quantitative and qualitative factors and often not being marketable, the DEA will be a highly appropriate methodology to measure the efficiency of TQM. DEA can transform information regarding inputs and outputs characterizing TQM activity, into a single efficiency score. Thus, this method can be viewed as another data generating process at the top hierarchy in the AHP.

We did not utilized the whole set of inputs and outputs. The advantage of keeping the number of inputs (X) and outputs (Y) small relative to the number of companies (N) is that as the ratio (X+Y)/N rises, the ability of the DEA to discriminate among companies falls significantly, since it becomes more likely that any given company will find some set of output and input weights which will make it appear efficient.

In this article, critical success factors used as inputs for DEA analysis are leadership, new product development, process management, human resources management, and customer satisfaction management. These factors have higher weights than other factors. Also, critical success factors used as outputs are quality improvement level compared to domestic companies and quality improvement level compared to foreign companies.

Other factors, such as, strategic quality planning, information analysis, organizational involvement, and environmental and safety management are not considered as input nor output factors, since their weights are relatively small. Note that we consider the output factors separately on the grounds that the products for domestic and international market can be different from each other and the systems for quality management for the two market can also be different.

3. Results

<Table 2> shows the index by TSS which is the weighted sum of critical success factors and the efficiency index by EMS in Korean companies. We denote the companies with and without ISO certification as ISO and NISO and LARGE and SMALL denote large and small-sized companies, respectively. The company size is determined on the basis of total revenue.

The mean value of the EMS index suggests that the average inefficiency for total sample is 21.1%, which implies that we can obtain 21.1% more output with the same level of effort to TQM activity. <Table 2> also indicates that the EMS index of the companies with ISO certification is higher than that of the companies without the certification (19.5% versus 18.3% of inefficiency) and the EMS index of the large-size companies is higher than that of the small-size companies (23.3% versus 16.9%). Note that higher value of EMS index imply that TQM activities are carried out inefficiently.

These results may be regarded as contradict to the traditional perception that the ISO certification and large company size would results in more efficient TQM activity. Possible explanation can be found in the fact that the ISO certification generally have emphasis on the process to control the quality, which, in turn, implies more weight on the input to establish the relevant process. This may result in the inefficiency, since more input is required to achieve the desired level of quality output. The same argument can be also applied to the inefficiencies of the companies in LARGE group.

< Table 2 > Index by TSS and efficiency index by EMS

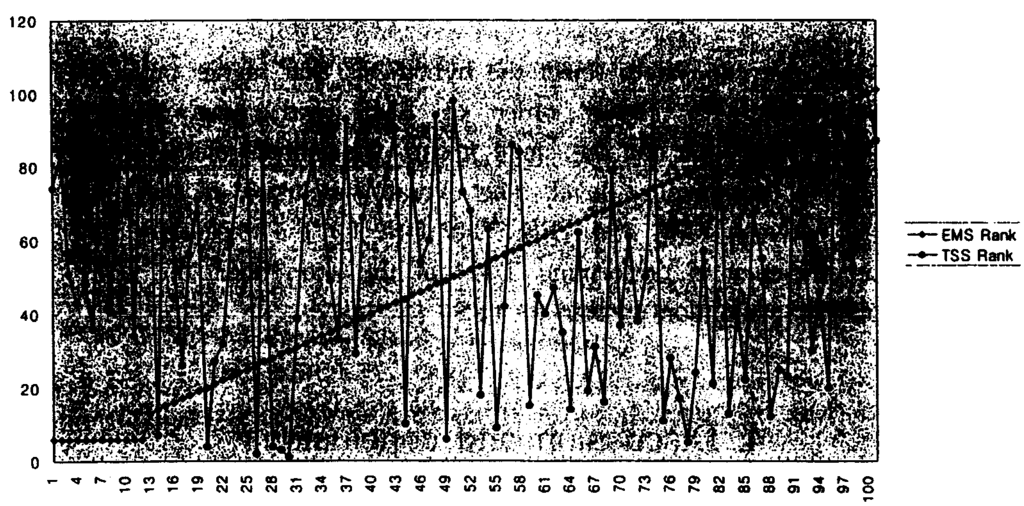
statistic		ISO	NISO	LARGE	SMALL	Total
efficiency index by EMS	Mean	1.195	1.183	1.232	1.169	1.211
	Maximum	2.025	1.728	2.025	1.483	2.025
	Minimum	1.000	1.000	1.000	1.000	1.000
	s. d.	0.197	0.145	0.219	0.118	0.201
index by TSS	Mean	67.621	63.703	67.727	65.348	67.124
	Maximum	81.860	78.020	81.860	78.490	81.860
	Minimum	48.280	53.910	48.280	53.910	48.280
	s. d.	7.231	6.208	7.133	7.299	7.271

Let us turn to the index from TSS based on the simple weighted sum of input and output. We obtain the average index of 67.1 for total sample with TSS. The companies with ISO certification provide relatively high value of TSS than the companies without ISO certification (67.6 vs. 63.7 for companies in ISO and NISO, respectively). As for the company size, the large companies appear to have higher value of TSS than the small companies. Note that higher value of TSS index imply that better performance in TQM based on the traditional evaluation concept.

The above observation in TSS suggests that the higher performance with TSS will not guarantee the efficiency of TQM activity (higher index in EMS). It means that the companies with quality awards based on TSS could provide a poor efficiency of TQM activity.

To rigorously investigate the potential relationship between TSS and EMS, this section presents the results of statistical hypothesis testing. By doing this, we will provide an indirect justification for the EMS index as a new basis to evaluate the performance of TQM.

Before turning to the testing results, it would be helpful to review the following <Figure 1> illustrating the rankings from TSS and EMS for the total sample. Note that twelve companies which have the equal level of EMS as best performers are given six as their orders in the figure. The intuition we can draw from the figure is that there may not be a positive or negative relationship between the orderings from the two evaluation systems.



< Figure 1 > Orderings from EMS and TSS for the total sample

The use of Spearman rank correlation coefficient as shown in <Table 3> permits us to perform a statistical test for the hypothesis that higher value of TSS is positively correlated with higher efficiency in EMS. We utilize the nonparametric test measure, since the DEA model used to obtain EMS is the deterministic model which does not include the statistical assumptions on the data. This, in turn, imply the resulting EMS have nonparametric properties. TSS is also the aggregated sum of subcomponents, which does not contain any statistical assumptions. Moreover, the absolute values of the two indexes are quite different from each other. With all these factors into consideration, we utilized the Spearman rank correlation for statistical hypothesis test.

The Spearman rank correlation coefficient for total sample and each subsamples are displayed along with the standardized z-value in the following table.

< Table 3 > Spearman rank correlation coefficient

Group	number of firms	Spearman rank correlation coefficient	Standard z value
ISO	73	0.146	1.240
NISO	28	0.0584	0.304
LARGE	74	0.0531	0.454
SMALL	27	0.363	1.850
TOTAL	101	0.095	0.955

From the table, we can safely reject the hypothesis that higher order of TSS is positively correlated with higher order of EMS with over 90 percent of significance level. Note that for the small group, we cannot reject the hypothesis with equal level of significance level. The overall conclusion is that there is no potential nexus between EMS and TSS. Therefore, for the executives who are in charge of the efficiency in performing TQM at the shop floor, the EMS can be said to be superior evaluation system to TSS.

4. Discussion and conclusions

This paper presents alternative perspective to evaluate the performance of TQM based on the efficiency concept. Conceptually, this efficiency criteria is valid on the grounds that as many other managerial activity, the TQM also requires scare resource to produce desired output. Thus, it also requires the principle of maximum output with minimum input.

To measure the efficiency of TQM, we adopt the DEA model, which has been extensively utilized for various issues of management. We add the simple weighted sum of input and output factors generated by AHP as representative case of traditional evaluation system to compare with EMS. This weighted sum of input and output has been adopted in many quality award.

Company specific TQM efficiency is obtained, which tells us on average 21.1% more quality output could be produced with given level of effort for quality improvement. The companies without ISO certification provides higher level of efficiency than the companies with ISO certification. Investigation of efficiency between different company size, we know that the small-size companies are more efficient than large-size companies. These EMS results contradict to that from TSS based on the simple weighted sum of input and output. Statistical hypothesis testing whether higher value of TSS guarantees higher value of EMS tells us that there is no statistical relationship between the orders from two evaluation system.

In conclusion, EMS can be a valid alternative to evaluate the TQM performance with a new perspective of efficiency.

References

[1] Adam, Jr., E. E.(1994), "Alternative quality improvement practices and organization performance," *Journal of Operations Management*, Vol. 12, pp. 27-44.

[2] Benson, P. G., Saraph, J. V., and Schroeder, R. G.(1991), "The Effect of Organizational Context on Quality Management: An Empirical Investigation," *Management Science*, Vol. 31, No. 9, pp. 1107-1124.

[3] Charnes, A., Cooper, W. W., and Rhodes, E. L.(1978), Measuring the efficiency of Decision Making Units, *European Journal of Operational Research*, Vol. 2, No. 6, pp. 429-444.

[4] Hanjoo, Yoo(April, 1997), A Study on the Quality Management Evaluation in Korean Industry, *Journal of the Korean Production and Operations Management Society*, Vol. 8, No. 1, pp. 123-136(written in Korean).

[5] Porter, L. J., and Parker, A. J.(1993), "Total Quality Management-the critical success factors," *Total Quality Management*, Vol. 4, No. 1, pp. 13-22.

[6] Saaty, T. L.(1980), *The Analytic Hierarchy Process*, McGraw-Hill, New York.

[7] Saraph, J. V., Benson, P. G. and Schroeder, R. G.(1989), "An instrument for

measuring the critical factors of quality management," *Decision Science*, Vol. 20, pp. 810-829.

[8] Seiford, L. M.(1996), "Data Envelopment Analysis: The evolution of the state of the art (1978-1995)," *The Journal of Productivity Analysis*, vol. 7, pp. 99-139.

[9] Zahedi, F.(1986), The analytic hierarchy process-A survey of the method and its application. *Interface*, 16(4), pp. 96-108.