A Model of Relationship between TQM Practices and Quality Performance in Indian Manufacturing Industry

Arun Kedar

Professor and Dean Academics,
Dr. Babasaheb Ambedkar College of Engineering and Research, Nagpur-441110, Maharashtra, INDIA
arunkedar64@gmail.com

Abstract*:*Admiration of quality management as an important factor holds the key to competitiveness in the worldwide market. Due to cut throat competition industries strive for better performance, which in turn generates more profit. Total Quality Management (TQM) is primarily found in manufacturing organizations to improve quality performance. A diagnostic research instrument has been designed to study the companies that have implemented TQM and mathematical models are developed from field data. The comparison of values of dependent term obtained from field data and the mathematical models shows that the mathematical models can be successfully used for the computation of dependent terms for a given set of independent terms. Indian industries can use TQM implementation factors to obtain detailed understanding of existing quality management practices and link them with quality performance measures. This paper presents an approximate generalized field data based model of relationship between TQM practice and quality performance in Indian context.

***Keywords*: Total quality management, quality performance, mathematical model, Indian industry.**

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I. INTRODUCTION

Different definitions of TQM have been presented over the years. [1] Claims that "attempting to define TQM is like shooting at a moving target". Some argue that TQM as a corporate culture characterized by increased customer satisfaction through continuous improvement, in which all employees in the companies participate actively. Total Quality Management focuses on control of business processes and customer satisfaction. Activities such as improvement, statistical control, supply control and quality engineering are ingredients of TQM.

TQM as a concept emanates from the academic field and has contributors such as Feigenbaum, Juran and Deming. The understanding of TQM is through different quality awards such as Deming Price, European Foundation of Quality Management, Malcolm Baldridge and so on. As TQM became popular around the world, the concepts of TQM were embodied in various national quality awards. Thus a comparison of different quality awards can provide insight into the similarities and differences in the understanding of TQM across the world. These quality awards are today looked upon as models of excellence. The basis for considering a quality award framework as a model of business excellence is that now it usually contains a set of quality criteria that include all areas of an organization's operation.

In developing country such as India some researcher have discussed the importance of critical factors such as top management leadership for quality, supplier quality management, employee training, process management and employee involvement for successful implementation of TQM [2, 3, 4, 5]. The study by [6] is perhaps the first comprehensive empirical study of quality practices in the Indian context.

This paper is primarily identifies the critical factors of TQM by interpreting the consensus amongst TQM organizations in Indian context and proposes the relationship between TQM practices and quality performance measures.

II. NEED OF FORMULATING APPROXIMATE GENERALIZED FIELD DATA BASED MODELS

The evidence concerning the relationship of TQM practices and quality performance is based on a wide range of indicators. The methodology of assessing the relationship of TQM practices and quality performance in various articles do not report quantitative interaction of the involved independent variables and the phenomenal responses in generalized field data based models. This relationship would be known as mathematical model of this complex system which is similar to man machine system. The field data based model for this system is formulated on the similar lines as of experimental data based model [7, 8] except the concept of test planning. On the basis of composed field data the values of independent and dependent variables are computed and an analytical relationship is established.

III. METHODOLOGY

A. Development of Research Instrument

The research instrument was developed in the form of questionnaire. A primary source of questions was [9, 10, 11, 12]. The questionnaire was developed through extensive literature review, field visits and suggestions from practitioners. Various award models were also considered in the process of questionnaire development. A Likert scale was employed for scoring responses, ranging from 1 "No emphasis" to 5 "Very strong emphasis". A total of 49 statements based on the dimensions discussed in literature review, are provided to be answered by the respondent. The final section of the questionnaire finds out 5 statements and respondents were asked to indicate impact of improvement programs practiced in organization on the quality attributes. Again a five-point Likert scale was employed for scoring performance responses 1 "No improvement" to and 5 "Very large improvement".

B. Independent Variables

This measure is based on the dimensions of TQM practice. Leadership, customer satisfaction, continues improvement, process management, strategic planning, education and training, team work, results and recognition, supplier quality management, information architecture and human resource management are considered in developing independent variables as the initial inputs to the implementation of TQM practice. A total of 49 statements based on the above dimensions are provided to be answered by the respondent.

C. Dependent Variables

This measure is based on the literature review of TQM and quality performance. Performance parameters such as customer satisfaction, defects, rework, claims from customer and scrap are used to identify the positive impact that the TQM has brought to organizations. Through the related literature review, this paper evaluates quality performance by measures expressed as dependent variables. Quality performance was explained by five measures as stated above. Table 1 provides five measures of quality performance to be answered by the respondents.

TABLE I. QUALITY MEASURES AS DEPENDENT VARIABLES

Sr. No.	Performance parameter	Dependent variable	Label
1	Quality	Customer satisfaction	Y1
2		Defects	Y2
3		Rework	Y3
4		Claims from customer	Y4
5		Scrap	Y5

D. Instrument Administration

The research instrument was administered to the managing directors, the general manager, production managers and quality manager etc. of a company. They are supposed to be the "thought" leaders with respect to quality management in their companies, therefore they were asked to participate in this study. The respondents who participated in study were chosen from Indian manufacturing firms pertaining to automobile, chemical, textile, food, electrical and electronics, furniture, and metal sector. The sample size was 226. The questionnaires were handed over personally to the respondent with prior appointment. Responses were also collected through postal mail and e-mail. The continuous follow up with the respondent's results in receiving 194 valid questionnaires with the responses rate of 85.84 %.

E. Factor Analysis

Exploratory principal components factor analysis was used. The basis behind this approach is that factors with a variance less than one are no better than a single variable, since every variable was standardized and has a variance of one. Using Principle Component Analysis and Varimax rotation, 10 factors were extracted that accounted for about 65.86 percent of the total variation in the observed ratings. Only the items with factor loadings ≥ 0.4 were considered for further analysis [13]. The KMO measure of sampling adequacy value for the item was 0.934 indicating sufficient inter-correlations. The Bartlett's Test of spehericity was also found to be significant (Approx. Chi square = 5987.889, $p < 0.001$). Table 2 shows the total and cumulative variance for each extracted factor by Principle Component Analysis.

TABLE II. EXTRACTED FACTORS FROM SAMPLED DATA

Factor	Eigen value	% of variance	Cumulative % of variance
1	5.169	10.549	10.549
2	4.837	9.871	20.420
3	4.410	9.000	29.420
4	4.249	8.671	38.091
5	4.014	8.191	46.282
6	2.744	5.600	51.882
7	2.177	4.442	56.324
8	1.669	3.407	59.731
9	1.519	3.101	62.832
10	1.483	3.027	65.859

IV. MODEL FORMULATION

It is necessary to correlate quantitatively various independent and dependent terms involved in this very complex phenomenon. This correlation is nothing but a mathematical model as a design tool for such situation. Quantitative relationship between independent terms and dependent terms can be expressed as: for the dependent term Y1,

$$Y1 = f(F1, F2, F3, F4, F5, F6, F7, F8, F9, F10) \quad (1)$$

Assuming the exponential form for the equation of this process, Equation 1 takes the form,

$$Y1=K1*[F1]^{a1}[F2]^{b1}[F3]^{c1}[F4]^{d1}[F5]^{e1}[F6]^{f1}[F7]^{g1}[F8]^{h1}[F9]^{i1}[F10]^{j1} \quad (2)$$

Using, the multiple regression analysis and appropriate computer program. The values of K_1, a1, b1, c1, d1, e1, f1, g1, h1, i1 and j1 for Equation 2 are obtained. Thus the generalized field data based model for this dependent variable Y1 is,

$$Y1 = 1.0*[F1]^{-0.0218} [F2]^{0.4000} [F3]^{0.3807} [F4]^{-0.0164} [F5]^{-0.3439} [F6]^{0.3112} [F7]^{0.2159} [F8]^{0.1475} [F9]^{0.0095} [F10]^{-0.082} \quad (3)$$

Equation 3 represent generalized field data based model for dependent variable Y1. On the similar lines, following four mathematical models were formulated for four dependent terms (viz. Y2 to Y5) from observed data for TQM practice.

$Y2 = 1.0002*[F1]^{0.4574} [F2]^{0.0143} [F3]^{1.0554} [F4]^{-0.4079} [F5]^{-0.8964} [F6]^{0.3334} [F7]^{0.4117} [F8]^{-0.0588} [F9]^{0.0874} [F10]^{0.0058}$

$Y3 = 1.0002*[F1]^{0.2143} [F2]^{0.0925} [F3]^{0.4484} [F4]^{-0.2456} [F5]^{-0.192} [F6]^{0.212} [F7]^{0.4275} [F8]^{0.1233} [F9]^{-0.0631} [F10]^{-0.0195}$

$Y4 = 1.0002* [F1]^{-0.3195} [F2]^{-0.028} [F3]^{0.6899} [F4]^{0.091} [F5]^{-0.1633} [F6]^{0.1628} [F7]^{0.4568} [F8]^{0.0666} [F9]^{-0.0158} [F10]^{0.0606}$

$Y5 = 1.0004*[F1]^{0.1509} [F2]^{0.4407} [F3]^{0.7118} [F4]^{-0.584} [F5]^{-0.5139} [F6]^{0.1432} [F7]^{0.5939} [F8]^{0.0881} [F9]^{0.0237} [F10]^{-0.0471}$

V. Sensitivity Analysis

Sensitivity analysis is carried out to find the robustness of the proposed model. Sensitivity analysis is used to study the impact of changes in performance improvement practices along the various factors (inputs) on quality measures. The inputs in the test samples are varied one at a time systematically up and down 10 per cent (±10%) from its base value holding other factors at their original values. Thus the total range of the introduced change is 20%. The change in output is calculated with the current input increased by 10 per cent and the current input decreased by 10 per cent. The total % change in output for ±10% change in input is shown in Table 3.

TABLE III. Sensitivity analysis of response variables

Factors	Y1	Y2	Y3	Y4	Y5
F1	0.4	9.2	4.3	6.4	3.0
F2	8.0	0.3	1.9	0.6	8.8
F3	7.6	21.1	9.0	13.8	14.2
F4	0.3	8.2	4.9	1.8	11.8
F5	6.9	18.1	3.9	3.3	10.3
F6	6.2	6.7	4.3	3.3	2.9
F7	4.3	8.3	8.6	9.2	11.9
F8	3.0	1.2	2.5	1.3	1.8
F9	0.2	1.8	1.3	0.3	0.5
F10	1.7	0.1	0.4	1.2	1.0

VI. Results and discussion

The indices of the model are indicator of how the phenomenon is getting affected because of the interaction of various independent terms in the models. The sequence of influence of indices of the various independent terms on each dependent term is shown in Table 4 and discussed below.

TABLE IV. Sensitivity Sequence of influence of independent factors on dependent terms

Dependent terms	Sequence of independent factors according to intensity of influence
Y1	F2, F3, F5, F6, F7, F8, F10, F1, F4 and F9
Y2	F3, F5, F1, F7, F4, F6, F9, F8, F2 and F10
Y3	F3, F7, F4, F1, F6, F5, F8, F2, F9 and F10
Y4	F3, F7, F1, F5, F6, F4, F8, F10, F2 and F9
Y5	F3, F7, F4, F5, F2, F1, F6, F8, F10 and F9

The following primary conclusions appear to be justified from the above model.

1] The absolute index of F2 is highest viz. 0.4. The factor ‘F2’ related to involvement of employees is the most influencing term in this model. The value of this index is positive indicating involvement of employees has strong impact on Y1.

2] The absolute index of F9 is lowest viz. 0.0095. Thus ‘F9’ the term related to employee empowerment is the least influencing term in this model. Low value of absolute index indicates the factor employee empowerment needs improvement.

3] The sequence of influence of other independent factors present in this model is F3, F5, F6, F7, F8, F10, F1, F4 having absolute indices 0.3807, 0.3439, 0.3112, 0.2159, 0.1475,0.082, 0.0218, 0.0164 respectively. The indices for F5, F10, F1 and F4 are negative indicating need for improvement.

4] The constant is this model is 1. As the value is 1 there is no magnification effect in the value computed from the product of the various terms of the model.

Sensitivity analysis indicates customer involvement and satisfaction factor turns out to be most sensitive for 80 % of the TQM initiative where as management support was least sensitive for 60 % of the TQM initiative thus needs strong improvement. The other most sensitive factors are involvement of employees and supplier involvement. Other factors which needs strong improvement are communication for information, employee satisfaction and employee empowerment in Indian context. Values are computed for mathematical models and comparison of the observed values and computed values by mathematical model of the dependent terms is shown in Table 5.

TABLE V. Comparison of the observed values and computed values by mathematical model of the dependent terms

Sr. No.	Y1	Y2	Y3	Y4	Y5
Mean Obs.	3.7	3.5	3.8	3.8	3.5
Mean Comp.	3.6	3.4	3.8	3.7	3.3
% Error	2.2	1.4	1.6	3.4	5.9

VII. Conclusion

The models have been formulated mathematically for the Indian manufacturing companies. The comparison of values of dependent term obtained from field data and the mathematical model are shown in Table 5. From the values of % errors, it seems that the mathematical models can be successfully used for the computation of dependent terms for a given set of independent terms. Indian industries can use TQM implementation factors to obtain detailed understanding of existing quality management practices and link them with quality measures.

Managers can use the instrument to evaluate the perceptions of quality management in their companies. These measurements can help decision makers identify those areas of quality management where improvements should be made. Also, comparisons of different companies or divisions can be made to help prioritize quality management efforts towards performance improvement.

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AUTHOR PROFILE

Arun Kedar is currently working as Dean Academics, Dr. Babasaheb Ambedkar College of Engineering and Research, Nagpur affiliated to Rashtrasanta Tukadoji Maharaj Nagpur University, Nagpur. He is also Professor in Mechanical Engineering Department. He has 30 years of experience in teaching. He has published more than 40 research papers in journals (International) and conference proceedings (International and National). He has guided four PhD scholars of which three research scholars have submitted thesis for their PhD degree. His area of specialisation is quality management and industrial engineering. He is the fellow, Institution of Engineers (India), Kolkata.