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AN ASSESSMENT MODEL TO CHARACTERIZE TQM SYSTEMS IN LARGE PHILIPPINE MANUFACTURING COMPANIES

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ABSTRACT

Current efforts in quality diagnostics are ineffective in providing organizations with a quantitative tool in the assessment of their level of Total Quality Management (TQM) adoption. A survey questionnaire of quantitative measures was formulated from concept mapping results and, subsequently, administered across 40 domestic manufacturing companies from various industries with a capitalization of at least PhP 50 Million. The latent statistical relationships among the variables were examined from which a long list of 28 validated key indicators was reduced to 18 variables using Principal Components Analysis and Multi-collinearity Analysis. Through Multiple Linear Regression, the model structure of the relevant indicators characterizing the level of TQM adoption was established. The resulting regression equation presents a classification model which confirms that the Level of TQM adoption is affected by the various indicators identified from the literature.

From the reduced set of 18 variables, four relevant indicators surfaced as predictor variables for determining the level of Total Quality Management Adoption for the sample companies. This exploratory work on large-scale companies highlights the possibility of organizing benchmarking efforts through quantifiable measures for continuously.

I. INTRODUCTION

From a synthesis of the various quality management approaches in the past, identified current practices and experts' opinion, a related paper [1] identified the main attributes in defining the level of adoption of TQM adoption at the organizational level. These were found to be composed of five attributes, namely : top leadership involvement, customer focus, human resource empowerment, continuous improvement, and process vitality.

The structure of the TQM attributes, indicating their linkages and construct relationships, is schematically shown in Figure 1 The TQM System Characterizing Attributes.

The current paper recognizes the need to identify the set of indicators that can be used to quantitatiyely measure and develop an assessment model to measure the level of adoption along these attributes.

IV. CONCLUDING REMARKS

A number of insights can be drawn from the results of the study. For the sample taken, the most critical indicators in TQM adoption that should be the concern of respondent manufacturing organizations are:

- Responsiveness to Customer Needs
- Alignment of Strategic Plans with Operational Implementation, and
- Level of Employee Empowerment and Involvement.

The top attribute that differentiates strongly among companies is ***Responsiveness to Customer Needs***, which can be gauged by *Percentage of Customer Complaints Solved or Addressed (CSOLV)*. This indicator register the highest coefficients in the regression model with a value of **2.454063**. TQM is an integrated management style that assures continuous improvement of the organization towards total customer satisfaction. TQM is hinged on customer focus. TQM indeed requires the management of customer relations, by extensively giving customer satisfaction survey feedback and making available the customer complaint information to managers. It is a change intervention geared towards delighting the customer, which is what differentiates TQM from other change strategies.

There are clear linkages among the TQM attributes. Figure shows that Top management leadership drives Human resource empowerment and Process Vitality. Human resource empowerment impacts Continuous Improvement which is linked with Process Vitality. Process Vitality is interlinked with Customer Focus. The regression equation developed, however, is not an objective function but a classification model. The regression model confirmed the research construct that the Level of TQM adoption is affected by the various relevant indicators identified from the literature.

In a highly competitive environment, survival entails comparing oneself with the others in the same group. While it is clearly futile to compare a company with another belonging to a different class, it is equally foolish to remain complacent by looking only at comparisons within the same level of maturity. This exploratory work on large- scale companies shows that there is a need for organizing benchmarking efforts by looking at quantifiable variables as measures for continuously improving the competitive advantages of companies.

The limitations of the model shall be its applicability only to the sample taken. Generalization to the manufacturing sector is not possible due to the limited number of samples and the limited number of companies implementing TQM in the Philippines.

Talavera (2000) found out that "there is significant association with TQM adoption and quality, business and organizational performance." The regression model developed will definitely help organizations to assess their current level of TQM adoption and design improvement interventions from there. Weak areas can be developed and strong areas continuously strengthened.

V. RECOMMENDATIONS FOR FUTURE WORK

The research findings also give some practical implications for the respondent companies that include:

a. The establishment of a systematic and efficient means for data collection of the critical TQM indicators in their organizations;
b. The collection of longitudinal data on these TQM indicators; and
c. The monitoring of the growth of the level of TQM Adoption through the years in order to check the impact of interventions on the bottom-line results.

The following are recommended for future research:

a. The implications of using this methodology to the growth of manufacturing industry can be rich and profound. As such, there is a strong potential for further inquiry in this area to develop a more comprehensive model that may span all the sizes of manufacturing industries in the Philippines.

b. For manufacturing organizations that have longitudinal business results data such as customer satisfaction and profitability, the conduct of time-series analysis to determine a link between specific TQM indicators and changes in business results is a logical continuation of this study.

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II. THE COMPONENTS OF THE ASSESSMENT MODEL

Forty respondent organizations consisting of domestic manufacturing companies with capitalization of at least P50 Million participated in the study. Using a total quality management index survey questionnaire validated through company visits and interviews with key informants, a long list of 28 indicator variables listed in Table 1 was generated. The sample size of 40 cases surveyed was deemed adequate on the basis of the "rule of 30" [2] and the recent findings of Guadagnoli and Velicer [3].

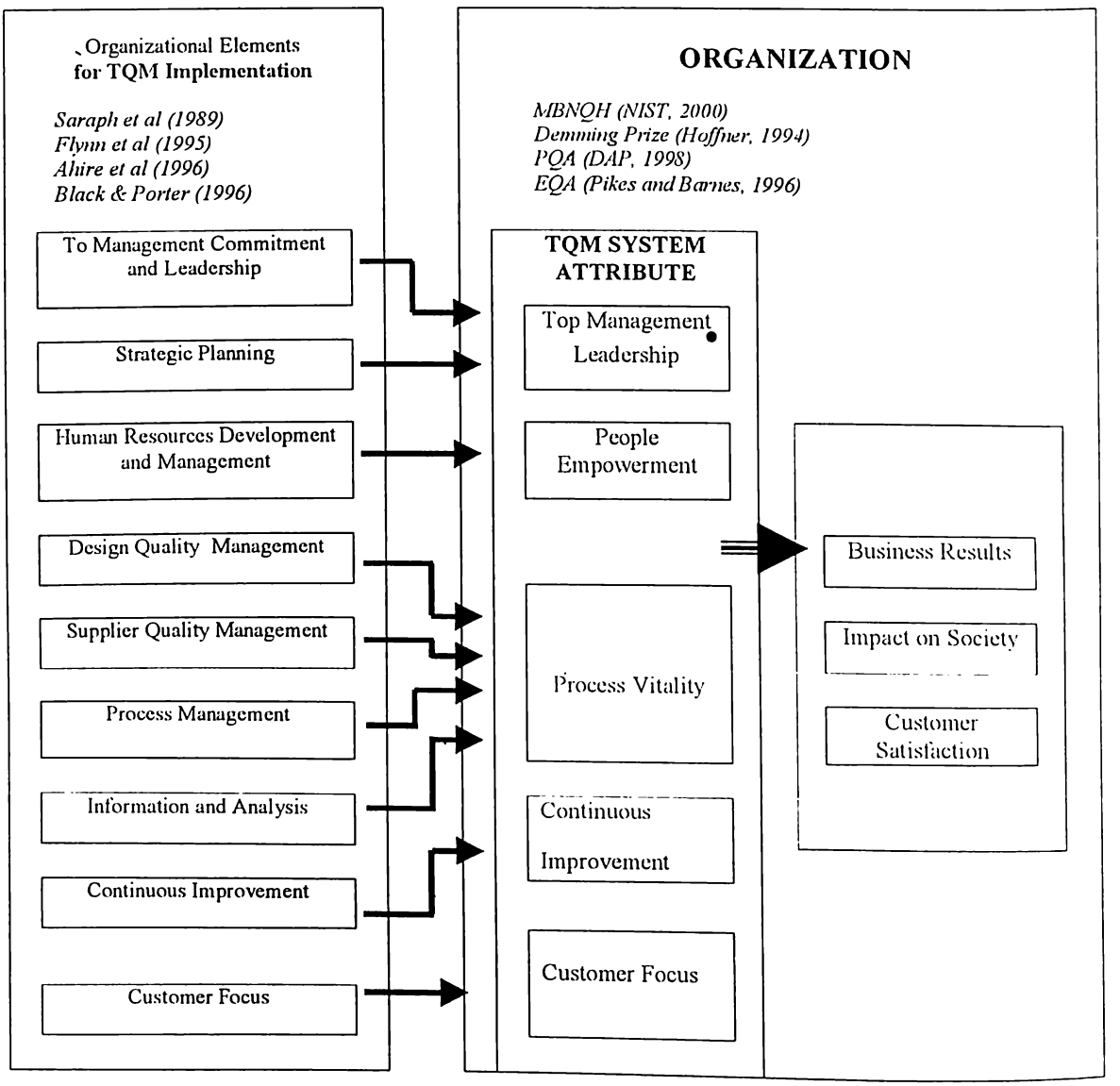


Figure 1. TQM System Characterizing Attributes [1]

Table 1: List of TQM Indicator Variables

No.	Indicator Label	Indicator Description
1	QSPENT	Percentage Amount of Money Spent on Quality-related activities/total budget per year
2	PMEAS	Number of Quality-related performance measures in Performance Appraisal Questionnaire per Total Number of Measures
3	FREQ	Frequency of Review of Strategic Quality Plans
4	ASQP	Approach to Strategic Quality Plans (SQP)
5	TQCOM	Time spent (Frequency x Duration of Regular Meetings and Information Campaigns) to Communicate Quality Policy to All Departments/Month
6	CSOLV	Percentage of Customer Complaints Solved or Addressed
7	FBACK	Actual Feedback Response time/Standard Response Time
8	FBQCI	Extent of Use of Customer Feedback in Quality/Continuous Improvement
9	AVAIL	Percentage Availability of Customer Complaints Facility/day
10	RETURN	Percentage Product Return Policies Upheld
11	CONCURR	Extent of Use of Concurrent Engineering
12	REWARD	Level of Rewards for Quality Performance/Improvement Efforts
13	TRAIN	Percentage of Employees who have attended TQM-related training programs
14	INFRA	Extent of Use of Infrastructure for Problem-Solving
15	SRELN	Type of Supplier Relationship
16	STRN	Amount of Money Spent on Training Suppliers on Quality Management
17	SEVALN	Level of Supplier Evaluation/Certification/Accreditation
18	SPECS	Clarity of Specifications to Suppliers
19	ALIGN	Alignment of Operational Quality Plans with Strategic Quality Plans
20	GHK	Good Housekeeping (5S+1) Rate
21	MAINT	Level of Maintenance Management System
22	VISD	Extent of Visual Display
23	PRSTD	Number of Processes Standardized/Potential to be standardized before TQM implementation
24	ANALYS	Level of Analysis of Performance & Cost Data to Support Improvement Priorities
25	COQ	Cost of Quality
26	WPS	Percentage of Workers Involved in Problem-solving activities
27	QCMET	Frequency of Meetings on Continuous Improvement-related Concerns per month
28	INVPS	Who are involved in continuous improvement programs/projects

By examining the latent statistical relationships among the variables, the long list of 28 indicators described in Table 1 was reduced to 21 significant variables using Principal Components Analysis (PCA) and Multi-collinearity Analysis (MCA) without losing much of the explained variance. The Principal Components (unrotated) and Rotated Components using various rotation methods were analyzed and components with loadings of at least 0.60 were retained. Table 2 lists the retained indicator variables together with the corresponding amount of variance explained.

Table 2. Reduced Variables

Factor Rank	FACTOR NO.	Ind. No.	Indicator Description	Factor Loading	Percentage Variance Explained
1	3	1	Approach to Strategic Quality Plans (ASQP)	.8670	10.65
		2	Clarity of Specifications to Suppliers (SPECS)	.6938	
		3	Alignment of Operational Quality Plans with Strategic Quality Plans (ALIGN)	.6060	
2	1	4	Percentage Availability of Customer Complaints Facility/day (AVAIL)	.9331	10.04
		5	Percentage Product Return Policies Upheld (RETURN)	.9097	
		6	Cost of Quality (COQ)	-.6128	
3	6	7	Extent of Use of Concurrent Engineering(CONCURR)	.7209	9.06
		8	Extent of Use of Visual Display and Error-Proofing Mechanism (VISD)	.7552	
4	7	9	Percentage of Employees who have attended TQM-related training programs (TRAIN)	.7803	8.94
		10	Type of Supplier Relationship (SRELN)	.6554	
		11	Total Time Spent (Frequency x Duration) of Regular Meetings and Information Campaigns to Communicate Quality Policy to All Departments/Month (TQCOM)	.6116	
5	4	12	Amount of Money Spent on Training Suppliers on Quality Management (STRN)	.9319	7.9
		13	Frequency of Meetings on Continuous Improvement-related Concerns per month (QCMEET)	.8971	
6	10	14	Level of Rewards for quality performance /improvement efforts (REWARD)	.7562	7.79
		15	Percentage of Workers Involved in Problem Solving (WPS)	.6182	
7	5	16	Percentage of Customer Complaints Solved or Addressed (CSOLV)	-.8321	6.87
		17	Actual Feedback Response time/Standard Response Time (FBACK)	-.7080	
8	8	18	Good Housekeeping (5S+1) Rate (GHK)	.7254	5.97
		19	Who are involved in continuous improvement programs/projects (WINVPS)	.8811	
9	2	20	Number of Quality-related performance measures in Performance Appraisal Questionnaire per Total Number of Measures (PMEAS)	-.8782	5.5
10	9	21	Frequency of Review of Strategic Plans (FREQ)	.7683	4.7

Factor 1 comprising 10.65% of the total variance is **the Alignment of Strategic Quality Plans with Operational Implementation** which is in linear combination with two indicators: Approach to Strategic Quality Plans (**ASQP**) and Clarity of Specifications to Suppliers (**SPECS**).

Factor 2 representing 10.04% of the total variance merges the three indicators: Percentage Availability of Customer Complaints Facility/day (**AVAIL**) & Percentage Product Return Policies Upheld (**RETURN**) and Cost of Quality (**COQ**) into one factor, the **Cost of Unquality**.

Factor 3 the **Quality of Product Design**, contributing 9.06 % of the total variance includes two indicators: Level of Concurrent Engineering (**CONCURR**) and Extent of Use of Visual Display and Error-Proofing Mechanism (**VISD**).

Factor 4 representing 8.94% of the total variance captures Percentage of Employees who have attended TQM-related training programs (**TRAIN**), Type of Supplier Relationship (**SRELN**) and Time (Frequency x Duration) of regular meetings & information campaigns to communicate quality policy to all departments/month (**TQCOM**). This refers to the **Impact of Top Management Commitment to Employee Training.**

Factor 5 giving 7.9% of the total variance combines Amount of Money Spent on Training Suppliers on Quality Management (**STRN**) and Frequency of Meetings on Continuous Improvement-related Concerns per month (**QCMEET**) which links two attributes process vitality and continuous improvement. These variables are just casually related.

Factor 6 capturing 7.8 % of the total variance has two indicators: Level of Rewards for quality performance/improvement efforts (**REWARD**) and Percentage of Workers Involved in Problem Solving (**WPS**). This factor measures the **Level of Employee Empowerment & Involvement.**

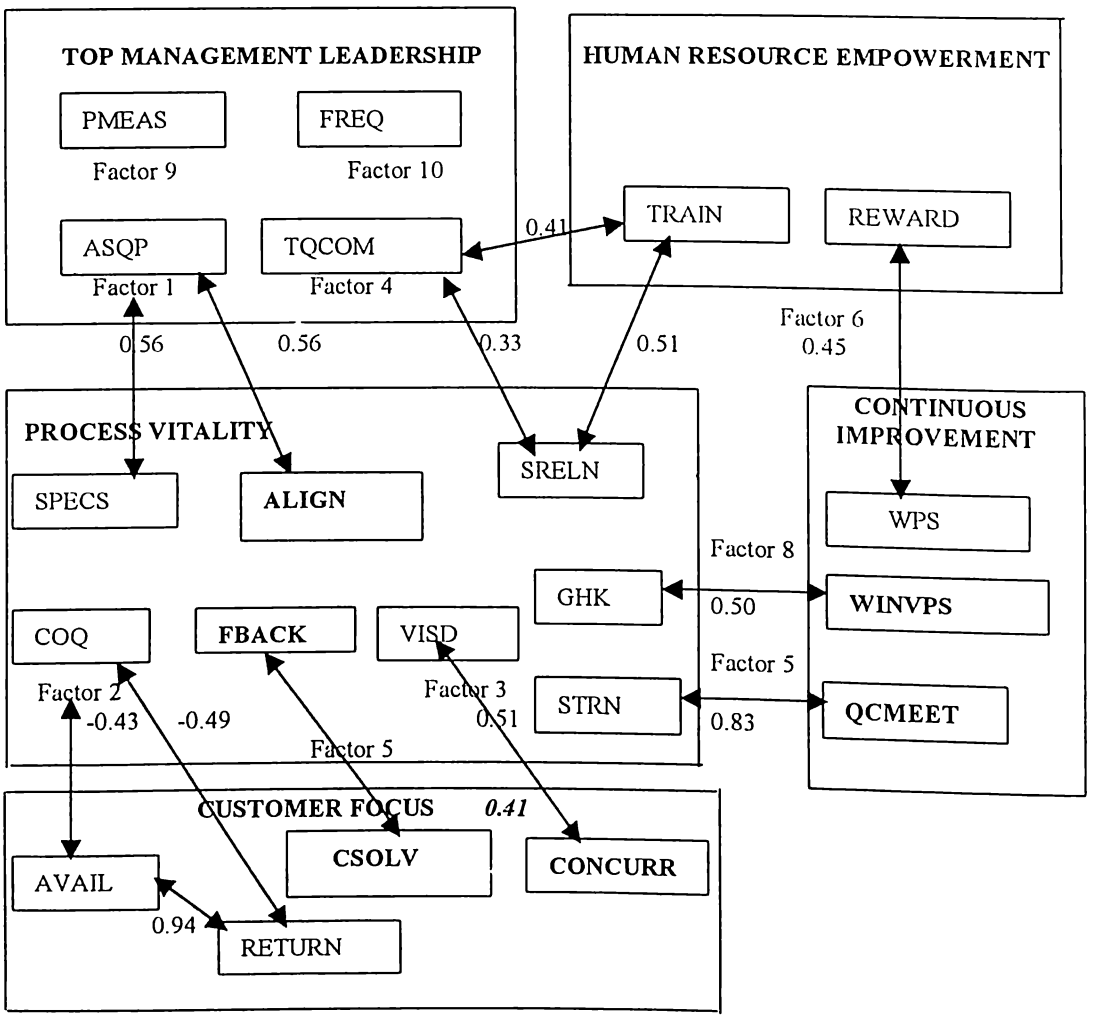
Factor 7 at 6.87 % of the total variance has two indicators: Actual Feedback Response time/Standard Response Time (**FBACK**) and Percentage of Customer Complaints Solved or Addressed (**CSOLV**). This factor is the **After Sales Service Index**.

Factor 8 comprising 5.97 % of the total variance consists of the Who are involved in continuous improvement programs/projects (**WINVPS**) and Good Housekeeping (5S+1) Rate (**GHK**).

Factor 9 representing 5.5% of the total variance is the **Extent to Which the Top Management Assumes Responsibility for Quality Performance** indicated by the Number of Quality-related performance measures in Performance Appraisal Questionnaire per Total Number of Measures (**PMEAS**).

Factor 10 representing 4.7 % of the total variance is Frequency of Review of Strategic Plans (**FREQ**) which indicates how top management is ***Monitoring and Analyzing Data Against Set Targets*** at the top-level.

In terms of indicator inter-relationships, Figure 2 highlights the path of linkages among the identified TQM attributes and indicators.



Legend: The numbers represent correlation coefficients between indicators;
F1=Alignment of Strategic Plans with Operational Implementation; F2=Cost of Unquality; F3= Quality of Product Design; F4= Impact of Top Management Commitment to Employee Training; F5=Amount of Training Suppliers and Frequency of QC Meets; F6=Level of Employee Empowerment; F7=After Sales Service Index; F8=Level of Employee Involvement in Good Housekeeping; F9=Extent of Top Management Responsibility for Quality Performance; F10=Frequency of Review of Strategic Quality Plans

Figure 2: Interlinkages Among TQM Attributes, Principal Components and Indicators

III. DEFINING THE PARAMETERS OF THE MODEL

The 40 sample companies were clustered based on the identified factors to determine the groupings that reflect the level of TQM adoption. Using Four-K means of clustering the sample companies were grouped as shown in Table 3.

Table 3. Four K-means Clusters (Statistica 2001)

Cluster 1	Cluster 2	Cluster 3	Cluster 4
10 cases	5 cases	11 cases	14 cases
3 ELECTRON1	9 PRINTING1	10 PLASTICS2	1 SEMICON1
6 METAL1	27 AUTOMOTI4	14 TEXTILE2	2SEMICON2
13 TEXTILE1	28 CEMENT2	20 METAL5	4 SEMICON3
15 PRINTING2	37 METAL7	22 MEDICAL1	5 PLASTICS1
17 AUTOMOTI3	39 AUTOMOTI5	23 RECYCLIN1	7METAL2
18 SEMICON5		24 FOAM1	8WOOD1
19FERTILIZ1		26 TIRE1	11 SEMICON4
25 METAL6		29 FOOD2	12ELECTRON2
32 METAL8		30 FOOD3	16 AUTOMOTI2
33 CEMENT3		35 PLASTICS5	21 BATTERY1
		36 PLASTICS6	31 BEVERAGE1
			34 PLASTICS4
			38 GLASS1
			40 CONSUMER1

The distinctiveness of the clusters was validated using multiple discriminant analysis, indicating that the four clusters are well discriminated from each other and that cases belonging to each group are more or less similar in many ways.

The next step calls for predicting the cluster using the identified indicators. Various models were tested and their characteristics were compared. Table 4 summarizes the characteristics of the following developed models:

Model 1: Cluster grouping $\Psi 1$ = **-0.09718** ***PMEAS*** **- 0.0199** ***FREQ*** **+ 1.759741** ***ASQP*** **- 0.02471** ***TQCOM*** **+ 3.17024** ***CSOLV*** **- 0.19441** ***FBACK*** **+ 1.200461** ***AVAIL*** **+ 0.457192** ***CONCURR*** **+ 0.83406** ***REWARD*** **+ 1.457574** ***TRAIN*** **- 0.15226** ***SRELN*** **- 1.2252** ***SPECS*** **- 0.79671** ***GHK*** **- 0.7474** ***VISD*** **-0.02264** ***COQ*** **+ 0.432895** ***WPS*** **- 0.01876** ***QCMEET*** **- 1.39981** ***WINVPS.***

Model 2: Cluster grouping $\Psi 2$ = **1.156348** ***ASQP*** **+1.504272** ***CSOLV*** **+ 1.380762*AVAIL* +0.957999*TRAIN* + 1.027205*REWARD* - 1.97611*WINVPS.***

Model 3: Cluster grouping $\Psi 3$ = **1.592986** ***ASQP*** **+2.454063** ***CSOLV*** **+ 0.268863** ***TRAIN*** **-1.32269** ***WINVPS.***

Model 4: Cluster grouping $\Psi 4$ = **1.67168** ***ASQP*** **+1.854082** ***CSOLV.***

Table 4. Comparison of the Models

Performance Measure/ Number of Indicator Variables	Model 1	Model 2	Model 3	Model 4
1. Multiple Correlation Coefficient R	0.98026050	0.97068657	0.95502737	0.94085219
2. Coefficient of Determination R^2	0.96091064	0.94223241	0.91207727	0.88520285
3. Adjusted Coefficient of Determination R^2	0.92892844	0.93203813	0.9023088	0.87916090
4. Standard Error of Estimate	0.79196	0.774444	0.92851	1.0327
5. Prediction Accuracy	-	47.5 %	50.0%	37.5%
6. Sample size ratio to Variables	2.22	6.7	10	20
7. Sum of Squares of Errors	-	0.675	0.925	1.2
8. Level of Significance	0.90	0.11	0.10	0.05

Hair (1995) prescribes that the ratio of the number of observations to the number of independent variables should never fall below five, meaning there should at least be five observations for each independent variable in the variate. On the basis of this criterion, the 18-indicator regression model does not qualify given only a 2.2 ratio of observations per indicator. The other three regression models have more than 5 observations and thus, meet the minimum required ratio.

Comparing the three models on the various performance measures, the best model is Model 3, the four-indicator regression model. The model was next evaluated and found valid based on the assumptions of Regression Analysis, namely: linearity, homoscedasticity, independence of residuals and normality.

The empirical data for large Philippine manufacturing companies exhibited that the relevant indicators of TQM characterization are:

1. Approach of Strategic Quality Planning Process (ASQP),
2. Percentage of customer complaints addressed (CSOLV),
3. Percentage of Employees who have attended TQM-related training programs (TRAIN), and
4. Who are involved in Continuous Improvement programs/projects (WINVPS).

While the level of TQM Adoption is higher in companies with higher values for the indicators ASQP, CSOLV, and TRAIN, it is lower in those with high values of WINVPS.

Higher levels of TQM Adoption are associated with companies with more proactive approach to Strategic Quality Planning, higher percentage of customer complaints solved or addressed, and more people in the organization that are trained in TQM-related training programs, the higher the level of TQM Adoption.

Finally, as the Problem Solving Process reaches the lowest level in the organization, the higher is the cluster grouping. Higher employee involvement shows that real empowerment has occurred.