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Characterizing Process Vitality In Large Philippine Manufacturing Companies

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ABSTRACT

*As one of the key attributes of **Total Quality Management**, **Process Vitality** represents the biggest in scope encompassing Product Design Management, Supplier Quality Management, Information and Analysis and Process Management. The paper attempts to provide a model to characterize the level of maturity of large manufacturing companies in the Philippines using key indicators of Process Vitality. Using multi-variate data analysis applied to a sample of 30 manufacturing companies, a predictive tool was developed to establish a taxonomy of companies on the basis of Process Vitality. That the resulting taxonomy can be organized using graphical representation of the level of maturity is demonstrated in terms of multi-axial diagrams from which insights on a company's plans, programs and procedures can be derived.*

I. INTRODUCTION

Studies completed in the past have confirmed that **Total Quality Management (TQM)** is indeed a complex management paradigm consisting of many attributes. Identified as one of the differentiating attributes of **TQM** is **Process Vitality (PV)** which gives an indication of the dynamic state of process improvement and system standardization in a company (Manalang, 2000). The elements of TQM relevant to Process Vitality as postulated by various TQM philosophers, gurus and researchers are summarized in Table 1, where 11 factors are highlighted.

From the key elements and constructs of PV, quantitative performance measures have been designed to form the backbone of a nationwide survey conducted in the later part of 1999 covering large manufacturing companies in the Philippines. While more than 80 respondents were gathered, the paper includes only a group of 30 companies which have fully accomplished the designed questionnaire as of this publication.

The paper focuses on Process Vitality and attempts to characterize the level of maturity of large manufacturing companies in the Philippines in terms of this attribute. The sections that follow examine the relevant indicators of PV, explaining in the process the key factors that drive this TQM attribute and the methodology used to surface these factors and their relevant indicators. From the chosen indicators, a predictive clustering tool was derived to estimate the level of maturity of manufacturing companies. Finally, the last part is devoted to examining a graphical approach to modeling the companies' level of PV maturity using a multi-axial phase diagrams, resulting in an informed taxonomy of companies which can be used to analyze the impact of each company's corporate plans, programs and procedures on Process Vitality (Doña, 1998, Herman,1988).

Table 1
Design of Indicators using Common elements of TQM (Manalang, 1999)

Process Vitality Factors	Summary Of Common Elements In The Process Vitality Factors	Generated Possible Performance Indicators
Information Analysis	Analysis of performance and cost data to support improvement priorities	Analysis of performance and cost data to support improvement priorities
Strategic Quality Mgmt	Process control and improvement of core processes in accordance with design	Defects rate; Internal rejects rate
Operational Quality Planning	Development/implementation of short-term plans/strategies focused on quality; Specificity of quality goals within the division; Comprehensiveness of the goal-setting process for quality within the division; Degree of comprehensiveness of the quality plan within the division	Manufacturing efficiency; Total productivity index; Presence/absence of operational quality plans
Supplier Relationship	Emphasis on long-term supplier relationships	Type of supplier relationship; Pesos spent on training suppliers on Quality Management since TQM Implementation
	Extent to which suppliers are selected based on quality rather than price or schedule	Level of : Supplier evaluation; Supplier certification & Supplier accreditation where considered are: 1. Suppliers' quality rather than price or schedule 2. Suppliers' technical 3. Suppliers' financial capability 4. Delivery performance 5. Cooperation of suppliers to resolve quality issues 6. Suppliers' willingness to improve quality
	Consideration of supplier's technical & financial capability , delivery performance; Cooperation of suppliers to resolve quality issues Suppliers' willingness to improve quality	
	Clarity of specifications provided to suppliers	Presence or absence of clear specifications provided to suppliers
Supplier Performance	Performance of supplied parts Conformance of supplied parts to specifications Reliability of supplied parts Durability of supplied parts	Average parts stock-out rate
Process Flow Management (Operating Procedures)	Extent to which process design is "foolproof" and minimizes the chances of employee errors	Accidents rate; Defects rate; Internal Rejects rate; Total Productivity Index; Manufacturing Efficiency
	Amount of preventative equipment maintenance	Presence/absence of preventive maintenance; Presence/absence of total productive maintenance
	Practice of good housekeeping (5S+1) principles	Good Housekeeping (5S+1) rate
Communication of Improvement Info	Emphasis on benchmarking non-competitors' products & services	Number of processes improved and standardized since TQM implementation;
	Visual display of quality information at work stations; Visual display of quality performance versus goals;	Presence/absence of visual display of: Quality information at work stations Quality performance versus goals
	Transmittal of defects information to specific work stations; Availability of scrap data; Availability of rework data	Presence/absence of scrap and rework data

II. The Indicators of Process Vitality in a Manufacturing Company

The Process Vitality Index measures the process quality, process management, quality information systems, workplace organization and good housekeeping of the organization. PV has the largest scope among all the attributes encompassing Product Design Management, Supplier Quality Management, Information and Analysis and Process Management. From a comprehensive review of theories developed in the past, PV driven by the 11 key indicators shown in **Table 2.**

Table 2
Process Vitality Indicators

	Indicator Description
SRELN	Type of Supplier Relationship
STRN	Amount of Money Spent on Training Suppliers on Quality Management
SEVALN	Level of Supplier Evaluation/Certification/Accreditation
SPECS	Clarity of Specifications to Suppliers
ALIGN	Alignment of Operational Quality Plans with Strategic Quality Plans
GHK	Good Housekeeping (5S+1) Rate
MAINT	Level of Maintenance System
VISD	Extent of Use of Visual Display and Mistake-proofing (Poka-yoke) Processes
PRSTD	Number of Processes Standardized/Potential to be standardized before TQM implementation
ANALYS	Level of Analysis of Performance & Cost Data to Support Improvement Priorities
COQ	Cost of Quality

Emphasis on long-term supplier relationships is best gauged by ***the Type of Supplier Relationship*** (whether supplier Partnership or Bidding System exists) and ***Amount of Money Spent On Training Suppliers On Quality Management Since TQM Implementation.***

The extent to which suppliers are selected based on quality rather than price or schedule can be predicted by the ***Level Of Supplier Evaluation, Certification & Accreditation***. This indicator measures how the following elements of the supplier's performance are monitored:

1. Suppliers' service/product quality (rather than price or schedule);
2. Suppliers' technical capability;
3. Suppliers' financial capability;
4. Delivery performance ;
5. Cooperation of suppliers to resolve quality issues; and
6. Suppliers' willingness to improve quality.

The Clarity of Specifications Provided To Suppliers dictates the quality of incoming raw materials and further defines the quality of the product and the processes to make them.

The ***Good Housekeeping (5S+1) Rate*** is a measure of how well the shopfloor is cleaned, systematically arranged and how the manpower sustains such orderliness.

The ***Alignment of Operational Quality Plans With Strategic Plans*** is a measure of how strategic plans are implemented and translated into operational plans throughout the organization.

Percentage Costs of Quality / Total Revenue is an indication of how much unquality depletes the total revenues of the company. Costs of Quality include Warranty Liability & Product Returns Costs, Cost of Defects, Cost of Internal Rejects, Cost of Rework, Cost of Scrap, and Cost of Accidents. Accidents Rate, Defects rate, Internal Reject Rate, Rework Rate, Scrap Rate are also subsumed under this measure. Measuring percentage costs of quality/total revenue also measures indirectly manufacturing efficiency and total productivity index.

The Presence/Absence of breakdown maintenance, Preventive Maintenance System, and Total Productive Maintenance are all considered under ***Level of Maintenance System.***

The Extent of Use of Visual Display and Mistake-proofing (Poka-yoke) Processes measures the use of tools and techniques in "mistake-proofing" processes through the use of limit switches, guide, pins, counters, alarm or error detectors, checklists and color-coding (Richardson, 1996). This is the application of ergonomics and behavioral sciences in the cognitive processing of workers to facilitate productivity.

Number of processes standardized/Potential Number of Processes to be Standardized, is the ratio of the number of processes standardized over the total number of processes in the company.

Analysis of performance and cost data to support improvement priorities are also hypothesized to be indicators for Process Vitality. It is the level of analysis of performance and cost data in the decision-making processes in quality improvement initiatives. It is intended to measure the quality of use of information across the various levels in the organization.

III. Defining the Relevant Indicators of Process Vitality

The relevant indicators of **Process Vitality** are defined using a three-pronged process. Initially, the global list of indicators of **TQM** are examined to include only those which are predictors of Process Vitality as synthesized from previous works. This is followed by re-expressing the resulting list of 11 indicators into orthogonal factors in the form of rotated principal components. Mathematically, the principal components $\mathbf{F}_i$ are linear combinations of the original indicators $\mathbf{X}_j$, expressed as

$$\mathbf{F}_i = [\lambda_{ij}]\,[\mathbf{X}_j], \quad \text{for } i=1,n \text{ and } j=1,n,$$

which represent a certain amount of the total variance in the data set. Using only the significant factors with explained variance of more than one (**Table 3**), the companies are clustered into groups having similar states of Process Vitality.

On the basis of the above, four (4) factors emerge as significant. Factor 1 explains 24% of the total variance and can be highlighted by Alignment of Operational Quality Plans with Strategic Quality Plans **(ALIGN)**, Extent of Visual Display **(VISD)**, Number of Processes Standardized/Potential to be standardized before TQM implementation **(PROCSTD)**.

Table 3
Indicators Relevant At Factor Loadings >=0.60

Indicators	Factor 1	Factor 2	Factor 3	Factor 4
SUPRELN	0.36	0.01	**0.64**	-0.17
TRNSUPP	0.12	**0.94**	-0.05	0.00
SUPEVALN	0.57	0.43	0.42	0.01
SPECSUP	0.24	0.14	**0.72**	0.15
ALIGN	**0.64**	-0.07	0.47	0.20
GHK	-0.07	0.04	-0.02	**0.96**
MAINT	-0.05	-0.14	**0.85**	-0.08
POKAYOKE	**0.87**	-0.04	0.05	-0.20
PROCSTD	**0.80**	-0.10	0.04	0.00
ANALYS	0.48	0.21	0.48	0.01
COQ	-0.23	**0.87**	0.02	0.08
Explained Variance	2.62	1.93	2.28	1.07
Proportion to Total	**23.78%**	**17.53%**	**20.74%**	**9.74%**

The second factor explains 21% of the total variance with Type of Supplier Relationship (**SRELN**), Clarity of Specifications to Suppliers (**SPECS**) and Level of Maintenance Management System (**MAINT**) as the principal indicators.Factor 3 registers 18% of the total variance , mostly contributed by Amount of Money Spent on Training Suppliers on Quality Management (**STRN**) & Cost of Quality (**COQ**). Finally, Factor 4, captures 10 % of the total variance, most of which are on account of Good Housekeeping (5S+1) Rate (**GHK**). The correlation matrix for all these indicators shows that there are no significant statistical relationships among the foregoing nine indicators (**Table 4**).

Table 4
Correlation Among Raw Indicators

	SRELN	STRN	SEVALN	SPECS	ALIGN	GHK	MAINT	VISD	PRCSTD	ANALYS	COQ
SRELN	1.00	0.08	0.50	0.42	0.45	-0.11	0.40	0.36	0.24	0.34	-0.14
STRN	0.08	1.00	0.42	0.12	0.03	0.04	-0.18	0.07	-0.04	0.17	0.70
SEVALN	0.50	0.42	1.00	0.41	0.56	-0.03	0.21	0.34	0.38	0.52	0.14
SPECS	0.42	0.12	0.41	1.00	0.47	0.05	0.46	0.25	0.27	0.32	0.12
ALIGN	0.45	0.03	0.56	0.47	1.00	0.03	0.26	0.41	0.43	0.47	-0.22
GHK	-0.11	0.04	-0.03	0.05	0.03	1.00	-0.06	-0.19	-0.06	0.00	0.13
MAINT	0.40	-0.18	0.21	0.46	0.26	-0.06	1.00	0.09	0.18	0.37	0.01
VISD	0.36	0.07	0.34	0.25	0.41	-0.19	0.09	1.00	0.67	0.49	-0.19
PROCSTD	0.24	-0.04	0.38	0.27	0.43	-0.06	0.18	0.67	1.00	0.21	-0.10
ANALYS	0.34	0.17	0.52	0.32	0.47	0.00	0.37	0.49	0.21	1.00	0.07
COQ	-0.14	0.70	0.14	0.12	-0.22	0.13	0.01	-0.19	-0.10	0.07	1.00

IV. A Taxonomy of Large Manufacturing Companies

Using K-means clustering technique, the sample companies (whose names were suppressed in the tabular presentation) were grouped on the basis of similarity in terms of scores on the factor indicators. Four (4) clusters emerge as shown in Table 5. The clustering technique systematically separates companies that are dissimilar along the chosen indicators, resulting in groups that are structurally more distinct from one another (instead of companies being more similar within a group).

Table 5
Resulting Cluster Groupings

Cluster A	Cluster B	Cluster C	Cluster D
Semicon2	Electronics1	Semicon1	Printing1
Semicon3	Plastics2	Plastics1	Plastics3
Wood1	Textile1	Metal1	Automotive2
Semicon4	Automotive1	Metal2	Fertilizer1
Electronics2	Semicon5	Medical1	Food2
Printing2	Battery1	Foam1	
Metal5	Metal6		
Recycling1	Automotive3		
Tire1	Food3		
Cement2			

As an extension of the analytical process, the indicators with significant loadings on the retained factors as identified in **Table 3** are then used to define a graphical approach to characterizing the clusters of companies. Scores of companies on each attribute are first normalized on the basis of the highest score attained by all companies, resulting in transformed scores ranging from zero to one. The resulting values are plotted on a multi-axial diagram to represent the process vitality of each company belonging to every group.

Taxonomic exercises have been conducted in the past in various fields such as Biology, Astronomy, and, lately, Urban Development. It is quite insightful to note that companies behave in much the same way as those systems amenable to classification on the basis of evolution along certain attributes. On the assumption that the programs, plans and procedures adopted by a company dictate to large degree its level of process vitality, then the current state is an indication of how it has evolved in the past. Possibly, this historical record can be summarized in multi-attribute diagrams to give an indication as to where companies are headed for if the current state of affairs are maintained. Companies belonging to one cluster are those which have followed a similar evolutionary track. Focusing on the companies' growth along each indicator, one company may be viewed as just a more mature "sibling" of another company in the same group; the less advanced companies will be expected to grow in a similar fashion if current corporate policies and procedures are maintained.

An examination of the multi-attribute diagrams of companies in **Figures 1** to **4** indicates some characteristics which are pervasive among the sample companies. Most of the companies are weak on **Amount of Money Spent on Training Suppliers on Quality Management (STRN)**, which is an indication of the value given by most companies to this element of **Process Vitality.** Ironically, most of these companies put a lot of emphasis on the **Cost Of Quality (COQ)**, which is a measure of how much is lost from non-adherence to quality standards.

The companies belonging to Cluster A (**Figure 1**) have medium to high scores on all attributes except on **Amount of Money Spent on Training (STRN)**. These are companies which have a most comprehensive view of process vitality among the sample clusters. An ideal multi-attribute diagram, is characterized by 7high scores on all nine indicators, resulting in a symmetrically robust polygon. Members of Cluster A may have been characterized by a robust polygon, if not because of their low scores in **STRN**.

Those belonging to Cluster B (**Figure 2**) have characteristically lower values on **Maintenance System (MAINT), Use Of Visual Display/Mistake-Proofing (VISD)** and **Type of Supplier Relationship (SRELN).** This results in a rather lopsided state of process vitality with high scores on **SPECS, GHK, COQ** and **PROCSTD**, while with low to medium scores on **ALIGN.**

Cluster C is composed of companies which appear to be moving in the same direction of development as those in Cluster A, although the former has distinct weaknesses in **GHK** and **Maintenance Systems (Figure 3)**.

Finally, cluster D may be viewed as those companies which are in a young state of development in terms of process vitality (**Figure 4**). These companies have more low attributes in various indicators.

These graphical models portray in a very compact manner, the state of Process Vitality in large manufacturing companies in the Philippines. The paper summarizes a methodology for defining such a characterizing model. The utility is determined by the extent to which the various scores can be related to companies policies, programs and procedures and, ultimately, to their resulting state of productivity and efficiency. This area is the subject of related researches which attempt to determine what companies have done in the past to get into their current state of maturity in Total Quality Management and to predict their likely future state given the current state of individual company affairs.

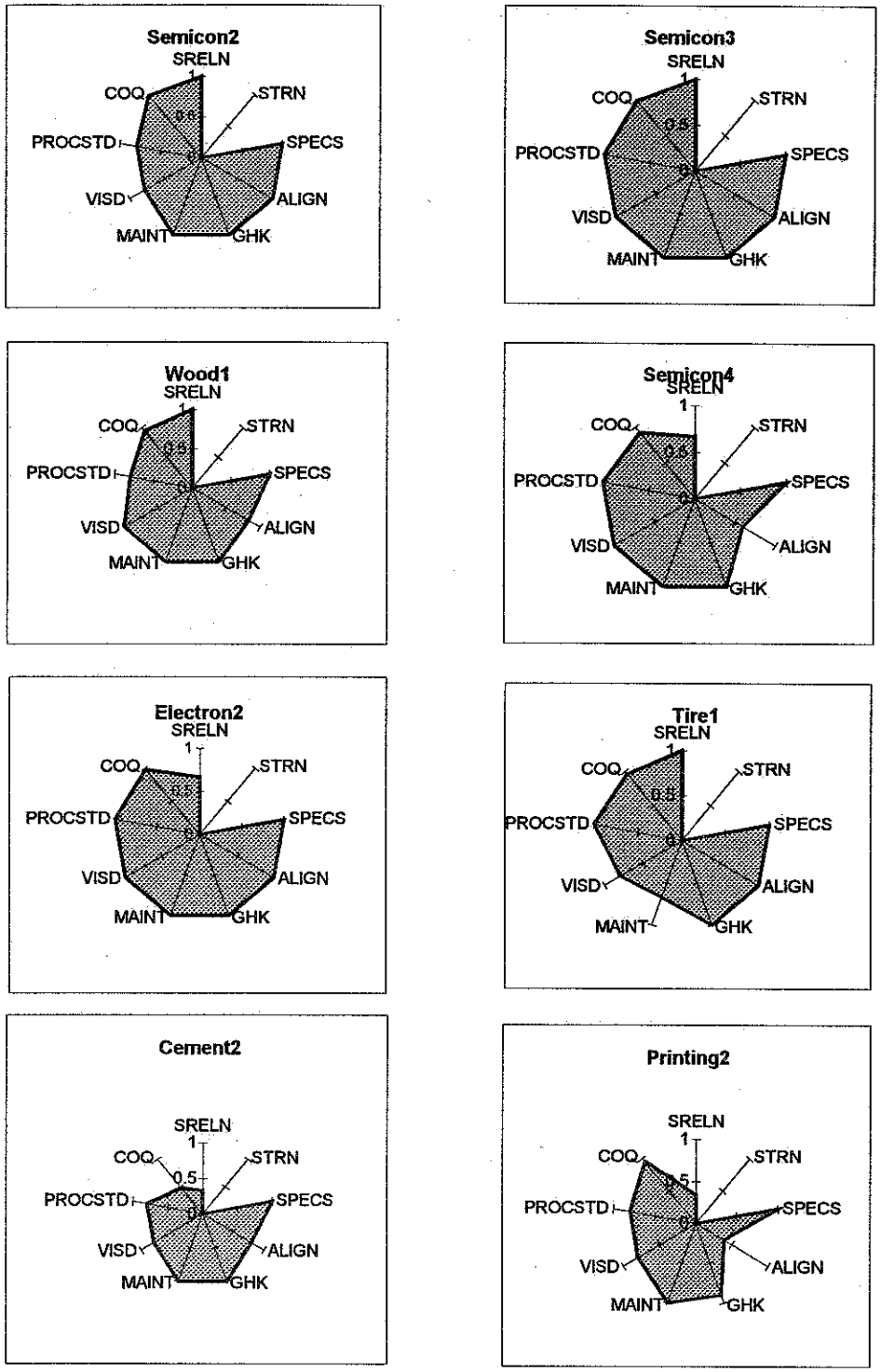

Figure 1 Multi-attribute Diagrams for Sample Companies in Cluster A

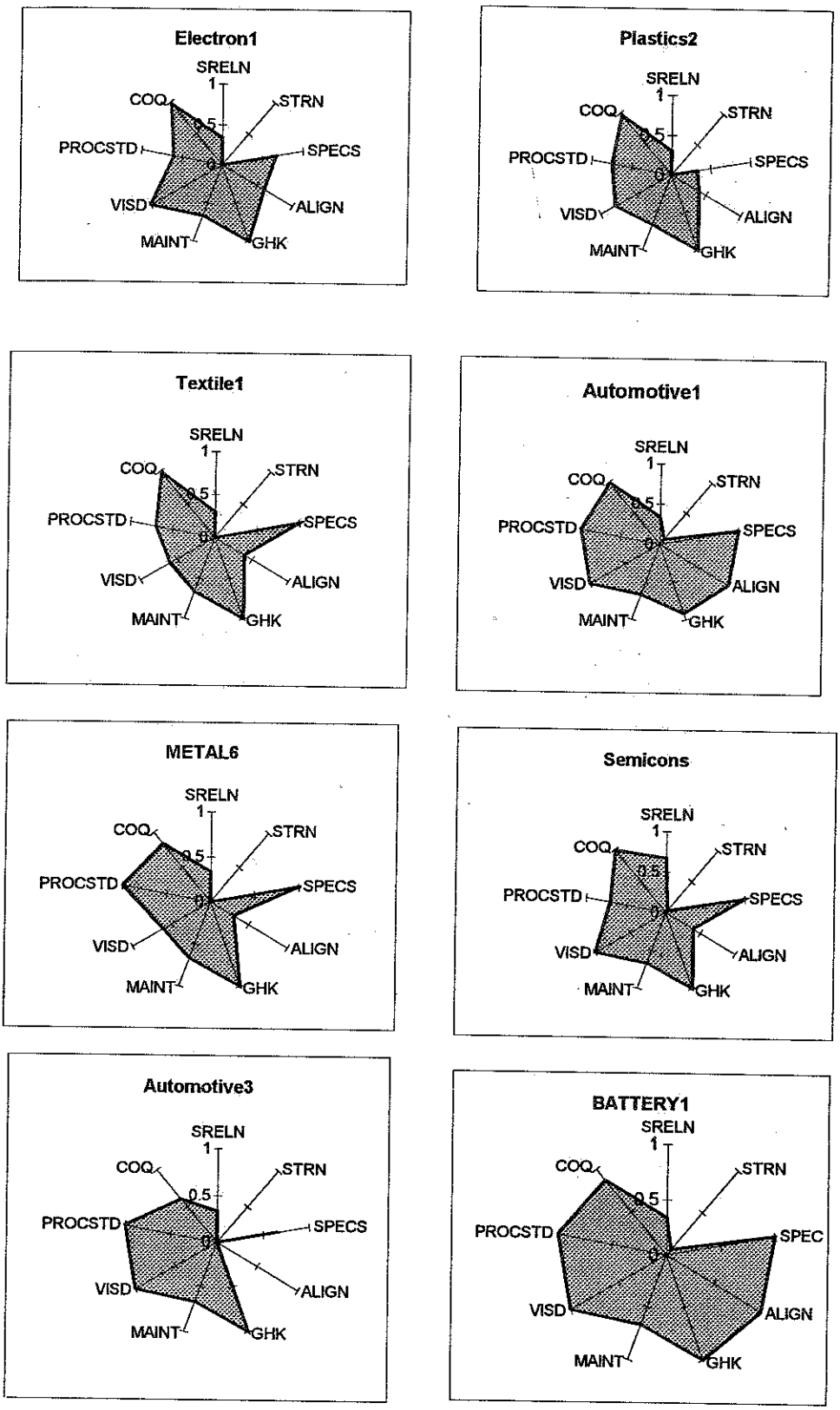

Figure 2 Multi-attribute Diagrams for Sample Companies in Cluster B

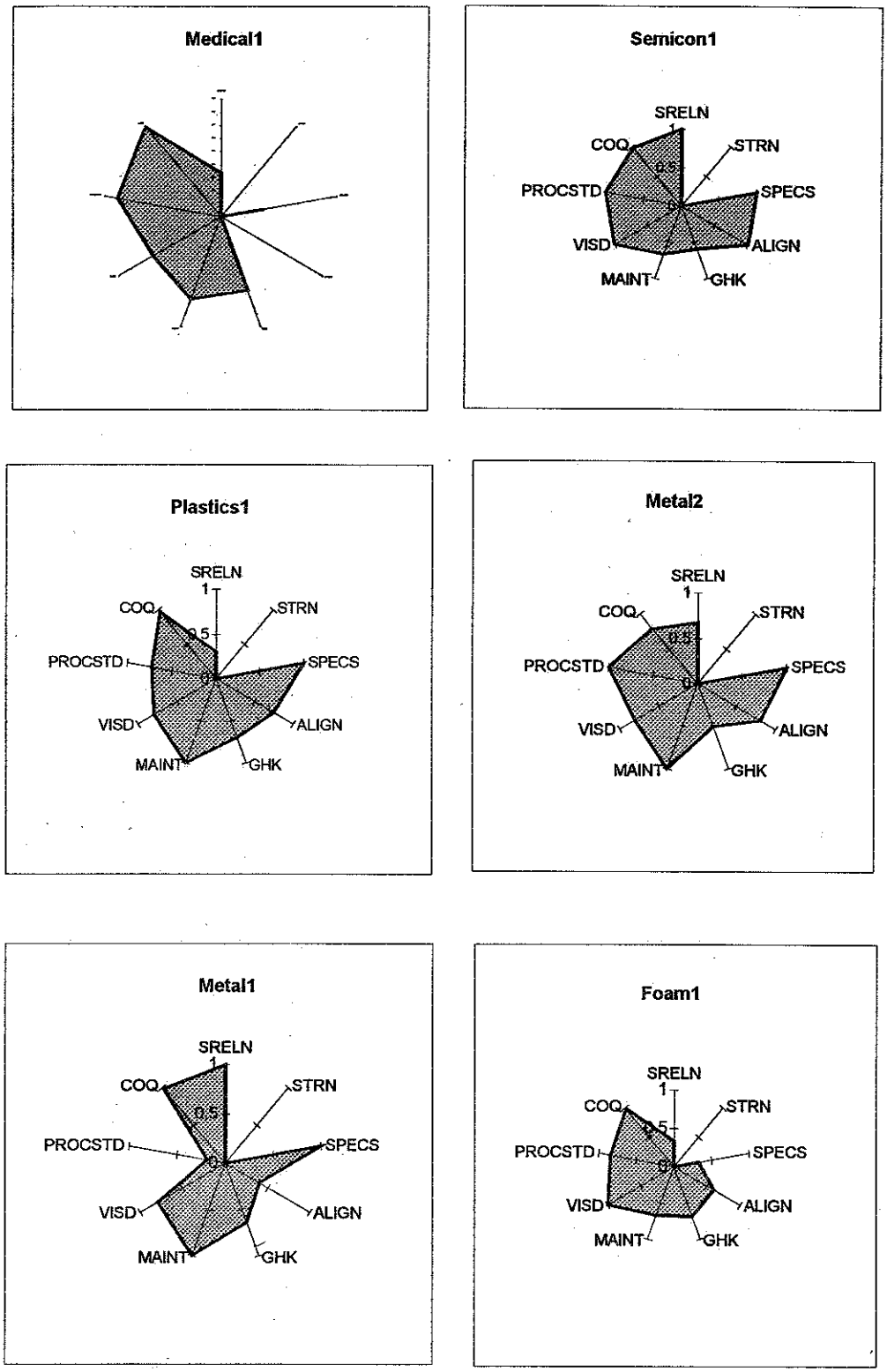

Figure 3 Multi-attribute Diagrams for Sample Companies in Cluster C

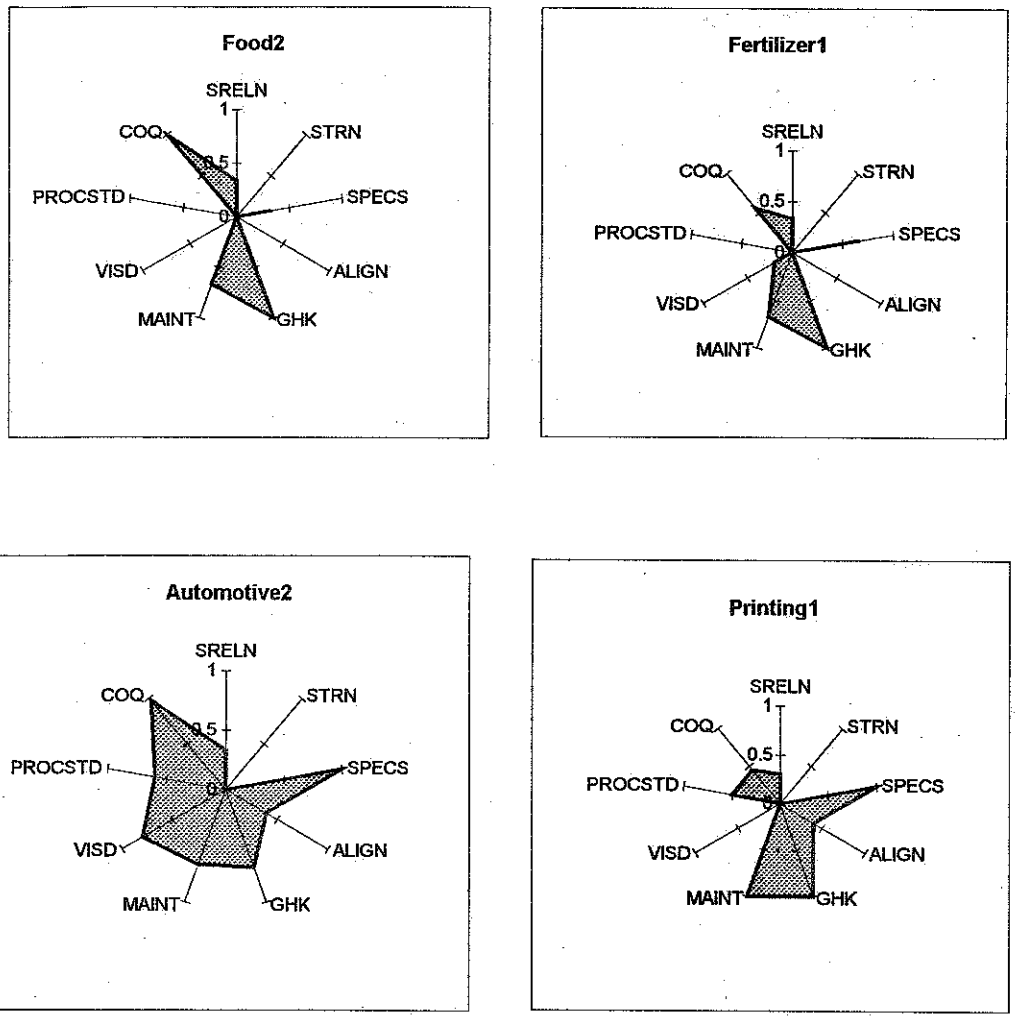

Figure 4 Multi-attribute Diagrams for Sample Companies in Cluster D

V. Concluding Remarks

While the foregoing analysis is just a part of a larger research on the complex attributes of Total Quality Management, the results are quite revealing and insightful. That the Process Vitality of large manufacturing companies can be modeled using a few descriptive indicators to summarize the complex characteristics of these companies have been demonstrated. There are preliminary indications that companies can be analyzed as clusters of similar companies with the same management styles and expected to evolve into the same mold of process vitality. Such tools of analysis can be a starting point for assessing the state of maturity of companies and predicting a possible management scenario if indeed it is recognized that one company in each cluster is a close replica of the others although in a different state of maturity.

It would be worthwhile to look at how companies view themselves along the same indicators to see whether there are prospects for improving the process vitality of manufacturing companies in the Philippines. This area of inquiry extended to other classifications of manufacturing c mpanies is the subject of a future research.

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