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SOME DETERMINANTS OF SATISFACTION AND QUALITY PERFORMANCE IN THE ELECTRONIC COMPONENTS INDUSTRY

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Total quality management and quality performance have been a principal focus of major manufacturing firms in the United States for nearly 20 years. As internal design and production processes have been simplified, standardized, and brought under statistical control, firms have looked to systems and channels outside operations to further reduce defectives and improve conformance quality. Because most manufacturers buy more than half their inputs from outside suppliers, practical approaches for improving incoming component quality are particularly relevant for reaching the goal of zero defects and total customer satisfaction.

Approaches for improving incoming component quality must consider at least two factors: suppliers' internal operational practices and the nature of the buyer-supplier relationship [9]. The extent that suppliers deploy quality management practices is an especially apropos measure of internal efforts to reach zero defects. However, for suppliers to take on the initiatives and invest the necessary money in training, equipment purchases, and repairs/upgrades often required to make dramatic quality improvements, they must have some assurance that the time and effort they spend will be worthwhile. The motivations buyers have offered their suppliers include a larger proportion of the buying firm's business for those suppliers that exceed quality and cost objectives, and assistance for suppliers that have put quality systems in place but have room for additional achievements. The various incentives and long-term mutual efforts for improving suppliers' quality, cost, delivery, and technical competencies, that are aimed at building and sustaining a nexus of capable suppliers, are known as *supplier development* [13, 18].

The objectives of this research are to investigate the relationship between two sets of supplier management practices and three measures of performance:

- Relationship between suppliers' internal quality management practices and measures of customer satisfaction, supplier satisfaction, and supplier quality performance.
- Relationship between buyers' supplier development practices and the same measures of customer satisfaction, supplier satisfaction, and supplier quality performance.

Although many variables influence quality performance and the satisfaction of customers and suppliers, this study examines the contribution to operational achievements made by two ongoing processes at the buyer/supplier interface.

THE STUDY

To explore the association between supplier quality management, supplier development, satisfaction, and performance, we surveyed the population of direct materials suppliers for a common customer manufacturer of electronic systems and equipment. The customer firm is a division of a *Fortune* 500 company that has been involved since the early 1980s in the fundamentals of supplier quality management and supplier development: data collection, supplier assessments, and supply base rationalizations; training and assistance for suppliers surviving the cuts; and increased sales volume along with rising requirements for suppliers exceeding expectations. The firm has maintained two-way communication via regular performance feedback to its suppliers as well as monthly and yearly solicitations to suppliers to rate its conduct as a business partner. The customer firm, which has won numerous quality awards, credits the improved management of its supply base as an important contributor to its quality successes.

Supplier development can be circumscribed as simply the discovery of new supply sources where no acceptable ones existed [18]. A broader definition encompasses a set of practices designed to cultivate long-term cooperative relationships that should help both buyers and

TABLE 1: Summary of Factor and Reliability Analyses

Construct	Factor Analysis		Reliability Analysis	
	Eigenvalue	Percent of Variance Explained	Inter-Item Correlation	Coefficient Alpha
Role of top management and quality policy	7.99	61.50	0.58	0.95
Employee relations	5.30	86.30	0.61	0.93
Training	5.11	63.90	0.58	0.92
Quality data and reporting	5.03	62.80	0.57	0.91
Product/service design	3.82	63.70	0.56	0.89
Role of the quality department	3.28	65.60	0.57	0.87
Process management/operating procedures	3.48	58.10	0.50	0.85
Supplier quality management	3.41	56.80	0.48	0.84
Customer satisfaction	3.14	78.50	0.70	0.91
Supplier satisfaction	3.09	77.20	0.69	0.90

suppliers better cope with market competition [18]. Our study adopted the broader definition and selected a representative set of supplier development practices from the literature [1, 6, 12, 13]. The supplier development practices queried include:

- Importance of quality (versus price or schedule) in this customer's selection of suppliers
- Utility of this customer's data-based supplier rating system
- Reliance by this customer on a few dependable suppliers
- Appropriateness of the education provided to its suppliers by this customer
- Usefulness of the technical assistance provided to its suppliers by this customer firm
- Involvement by this customer in its suppliers' product development process
- Extension of long-term contracts to its suppliers by this customer
- Clarity of specifications provided to its suppliers by this customer

The quality management practices included on the questionnaire were based on a previously validated survey instrument [16]. The practices and their associated constructs, which were drawn from the lessons of quality gurus such as Deming [3, 4], Juran [11], Crosby [2], Ishikawa [10], and Garvin [7, 8], cover a broad range of factors that can potentially improve product quality and they closely reflect the categories on the Baldrige award. The eight constructs are:

- Role of top management and quality policy
- Product/service design
- Supplier quality management
- Role of the quality department
- Process management/operating procedures
- Quality data and reporting
- Employee relations
- Training

(See [5] for a complete list of items associated with each construct.)

The performance measures were derived from two sources. To measure customer and supplier satisfaction, our study adopted a satisfaction construct that had been corroborated by previous research on interorganizational relationships [17]. The items composing that construct are:

- Extent that this customer (supplier) carries out its commitments agreed to with your firm
- Extent that the relationship between you and this customer (supplier) is productive
- Extent that the time and effort spent to develop and maintain this relationship is worthwhile
- Extent that you are satisfied with this relationship

All perceptual measures (the supplier development items, the quality management practices, and the customer and supplier satisfaction criteria) were evaluated on five-point Likert scales in which 1 = No Extent, 3 = Some Extent, and 5 = Great Extent. Five-point scales were chosen over seven-point scales because of earlier groundwork that established no significant improvement in reliability (as measured by coefficient alpha) after five scale points are surpassed [14].

The common customer firm whose supply base we were surveying provided the supplier quality performance data. These are the actual objective quality measures the customer firm uses to evaluate its suppliers' performance for contractual compliance and contractual renewal purposes. Although a variety of objective

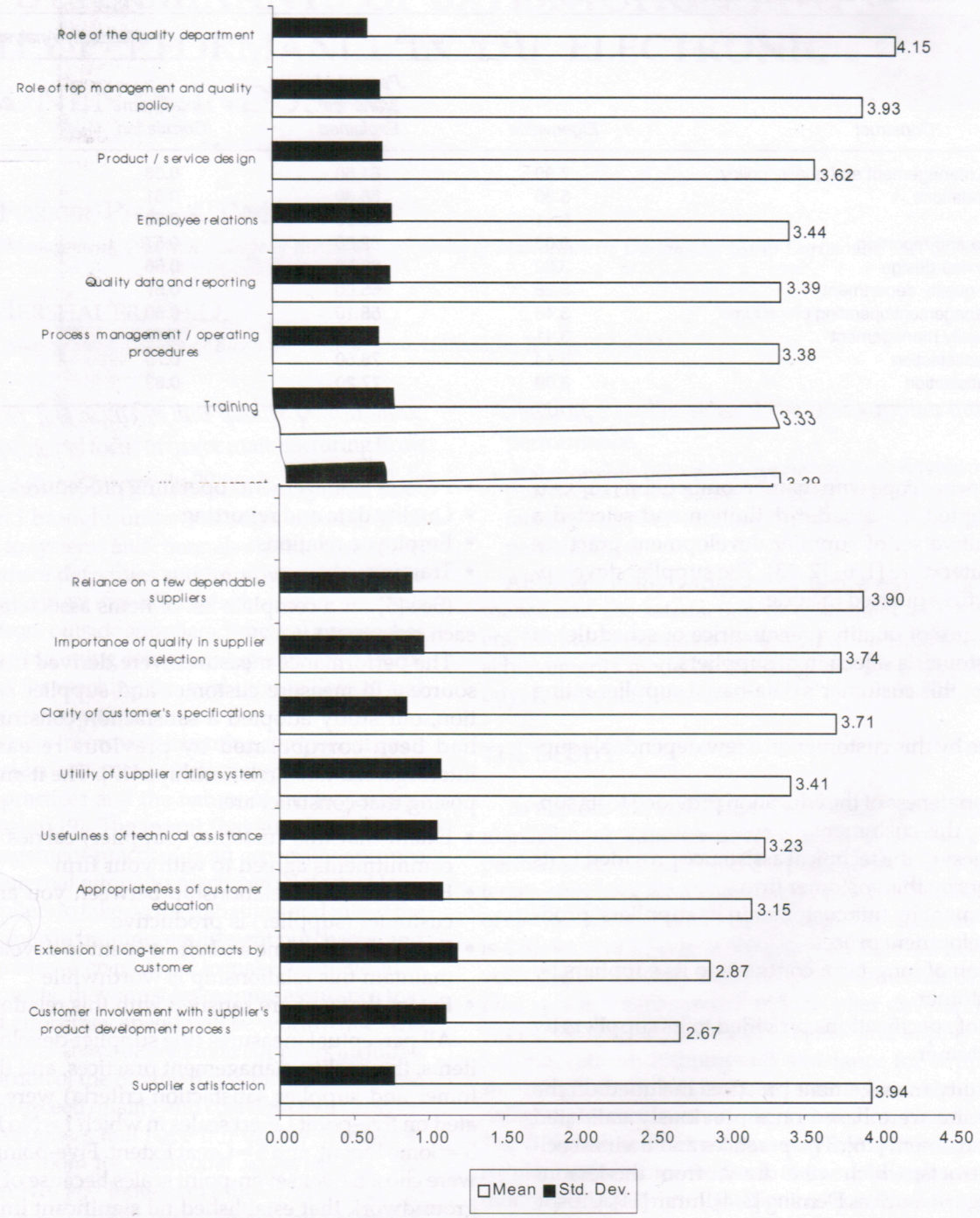

FIGURE 1: Descriptive Statistics: Suppliers' Perceptions

quality data are used, the customer's most comprehensive benchmark is defective parts per million (DPPM). This statistic includes defects found in investigations at the supplier's facility, receiving checks at the customer firm's plant, production line failures, final inspection rejections, and field failures that can be traced back to an individual part. To avoid calibration problems and to make it easier to compare results, the DPPM data were

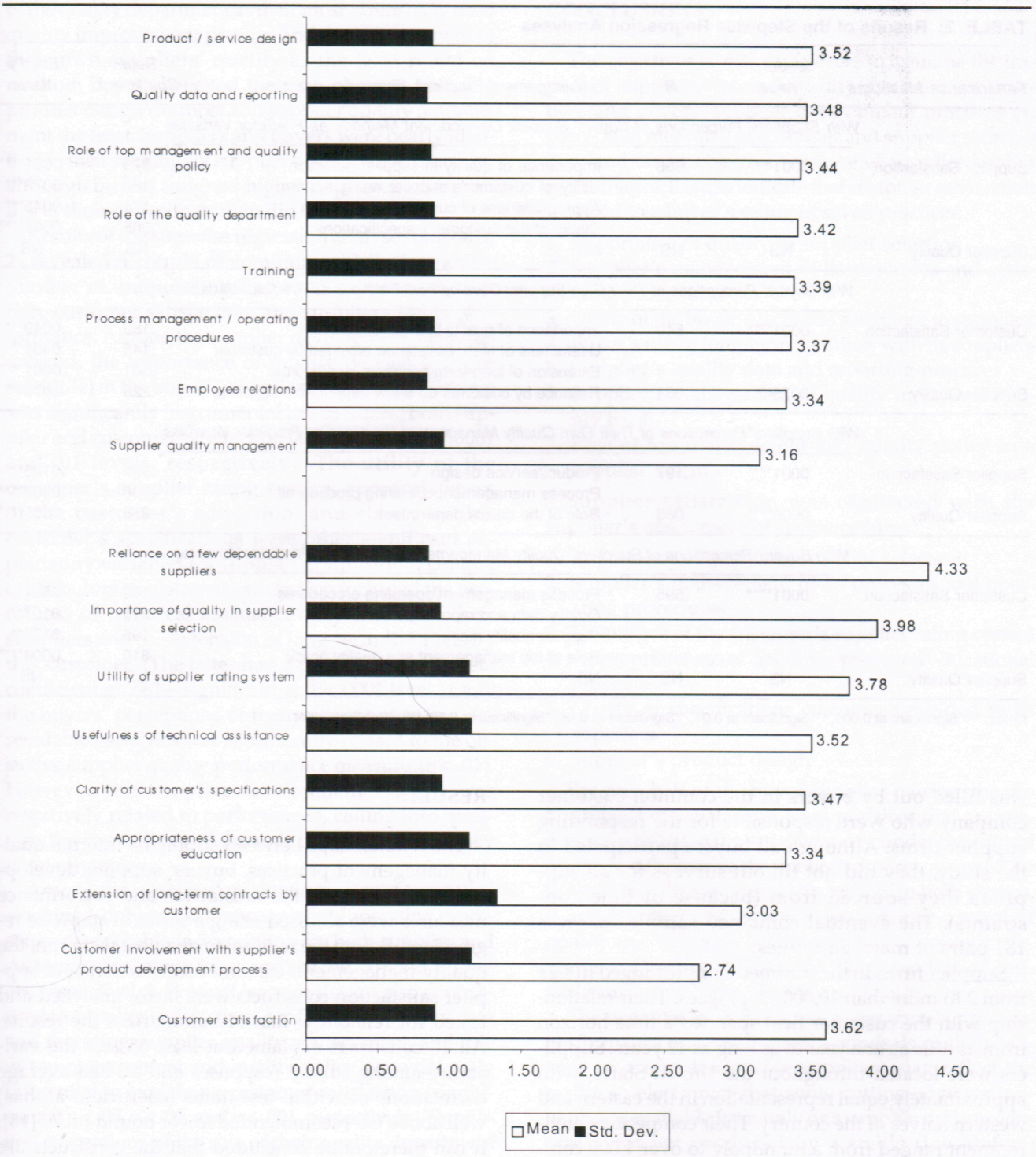

FIGURE 2: Descriptive Statistics: Buyers' Perceptions

inverted and normalized to the interval 0-1: a value of 0 on the normalized scale corresponds to all defectives (no acceptable parts) and a value of 1 corresponds to zero defectives (all parts passing inspection).

Survey instruments were mailed to 421 suppliers of electronic components; 292 responses were received for a usable rate of 69%. After surveys were returned by the suppliers, a "mirror" questionnaire

TABLE 2: Results of the Stepwise Regression Analyses

Performance Measures	Model p Value	R^2	Management Practices Entered	Beta Coefficient	Entry p Value
With Suppliers' Perceptions of Buyers' Supplier Development Methods as Predictor Variables					
Supplier Satisfaction	.0001****	.556	Importance of quality in supplier selection	.279	.0001**
			Utility of customer's supplier rating system	.180	.0073**
			Appropriateness of customer's education	.174	.0045**
			Clarity of this customer's specifications	.365	.0001**
Supplier Quality	NS	NS	NS	NS	NS
With Buyers' Perceptions of Their Own Supplier Development Methods as Predictor Variables					
Customer Satisfaction	.0001****	.549	Importance of quality in supplier selection	.183	.0049**
			Usefulness of tech. assistance provided by customer	.145	.0461**
			Extension of long-term contracts by customer	.581	.0001**
Supplier Quality	.0075***	.051	Reliance by customer on a few dependable suppliers	–.225	.0075**
With Suppliers' Perceptions of Their Own Quality Management Practices as Predictor Variables					
Supplier Satisfaction	.0001****	.197	Product/service design	.199	.0125**
			Process management/operating procedures	.306	.0002**
Supplier Quality	.0005****	.066	Role of the quality department	–.258	.0005**
With Buyers' Perceptions of Suppliers' Quality Management Practices as Predictor Variables					
Customer Satisfaction	.0001****	.595	Process management/operating procedures	.185	.0561*
			Quality data and reporting	.215	.0107**
			Supplier quality management	.195	.0128**
			Role of top management and quality policy	.310	.0008**
Supplier Quality	NS	NS	NS	NS	NS

Notes: ****Significant at 0.001, ***Significant at 0.01, **Significant at 0.05, *Significant at 0.10, NS - Not Significant

was filled out by buyers in the common customer company who were responsible for the responding supplier firms. Although all buyers participated in the study, they did not fill out surveys for all suppliers they sourced from (because of time constraints). The eventual combined sample size was 181 pairs of matched replies.

Supplier firms in the trimmed sample ranged in size from 2 to more than 10,000 employees. Their relationship with the customer firm spanned a time horizon from as little as one year to as long as 42 years. Suppliers were located throughout the United States, with approximately equal representation in the eastern and western halves of the country. Their competitive environment ranged from a monopoly to over 1,000 competitors. And suppliers manufactured a variety of commodity categories, including semiconductors, connectors, mechanical components, microwave components, passive components, printed wiring board, chemicals, and plating.

RESULTS

The relationships between suppliers' internal qua ity management practices, buyers' supplier develo ment methods, and the satisfaction and performan measures were assessed using a series of stepwise r gressions. Before the regression analyses were run, t quality management, customer satisfaction, and su plier satisfaction constructs were factor analyzed ar tested for reliability. Table 1 summarizes the resul All 10 constructs explained at least 55% of the va ability among survey responses and all had avera correlations of within-test items (coefficient alpha well above the recommended lower bound of .70 [1 It can therefore be concluded that the constructs a reliable indicators of the concepts they are intended measure. To preserve the scope of activities querie the eight supplier development practices were enter as items and not reduced through factor analysis.

Figures 1 and 2 illustrate the average values for ea quality management construct, supplier developme item, and satisfaction construct. Suppliers rated the r

of the quality department as their most extensively used quality improvement practice and the management of their own suppliers' quality as the least relied on method. Buyers believed their suppliers to be using product design the most and supplier quality management the least. Suppliers and buyers were nearly identical in their rankings of supplier development practices, although buyers assigned higher implementation values to their own efforts than did their suppliers.

Results of the stepwise regression analyses (see table 2) revealed a couple of common contributors and a number of unique contributors to supplier satisfaction, customer satisfaction, and supplier quality performance. Among the supplier development methods entered, the importance of quality (versus price or schedule) in the buyer's supplier selection procedures was significantly instrumental in explaining both supplier and customer satisfaction (significant at the .0001 and .01 levels, respectively). The utility of the customer's supplier rating system, appropriateness of the customer's education, and clarity of this customer's specifications were other significant explanatory variables for supplier gratification. Unique contributors to customer satisfaction included the usefulness of technical assistance they extend to their suppliers and the extension of long-term contracts by this customer. (The latter had a particularly high beta coefficient of .581—significant at the .0001 level.) Only the buyers' perceptions of their reliance on a few dependable suppliers was significantly related to the objective supplier quality performance measure ($p < .01$). However, this supplier development variable was negatively related to performance, calling into question the capabilities of the reduced supply base they were relying on.

Among the suppliers' quality management practices examined, only process management/operating procedures was notable in accounting for both supplier and customer satisfaction (significant at the .001 and .10 levels, respectively). Product/service design also contributed to supplier satisfaction ($p < .05$), while quality data and reporting, supplier quality management, and role of top management and quality policy were uniquely influential in explaining customer satisfaction (significant at $p < .05$, $p < .05$, and $p < .001$, respectively). Suppliers' perceptions of the role of their quality department was the singular significant explanatory variable in the stepwise regression with supplier quality performance ($p < .001$). However once again, the relationship between predictor and dependent variables is a negative one, making one wonder how the supplier firms involved achieved the required level of quality.

CONCLUSIONS

The objectives of this study were to examine the impact of suppliers' internal quality management practices and buyers' supplier development practices on perceptual measures of customer and supplier satisfaction, and on an objective measure of supplier quality performance. Results indicate that customer satisfaction is linked to a buyer's rating of seven practices:

1. Importance of quality in supplier selection
2. Supplier's management of its processes and operating procedures
3. Utility of the buyer's technical assistance to suppliers
4. Buyer's use of long-term contracts with its suppliers
5. Supplier's quality data and reporting practices
6. Supplier's management of quality in its own supply base
7. Role of top management and quality policy in a supplier's firm

Supplier satisfaction was connected with the supplier's assessment of six procedures:

1. Importance of quality in supplier selection
2. Supplier's management of its processes and operating procedures
3. Usefulness of the customer's supplier rating system
4. Appropriateness of customer-provided educational programs
5. Clarity of specifications customer provided to its suppliers
6. Supplier's product design

For each half of the buyer-supplier pairing, the determinants of satisfaction were practices that are precise and explicit to the satisfied party, under the control or major influence of the contented party, assessed by the gratified group, and highly visible to both parties. It appears that clarity, transparency, and control of quality management and supplier development programs are the key influential factors that lead to mutual satisfaction among buyers and suppliers.

The negative relationship between supplier quality performance and the buyers' appraisals of their reliance on a few dependable suppliers may reflect the reality in electronics that some cutting-edge components are available from only one supplier and are generally not yet produced by a stable (low-defect) production process. It may also indicate that the customer firm has become so lean in trimming its supply base that it has reached a sickly state of anorexia in which quality is "out of control" and cost or other issues have taken precedence in supplier assessment. Although these explanations are conjectures on our part, they are plausible explanations.

The negative relationship between supplier quality performance and suppliers' rating of the role of their own quality departments may reflect the fact that some suppliers' processes are not yet capable of meeting the target quality levels set for them by the customer company. To fulfill their contractual obligations in terms of minimal defects, these suppliers may be resorting to an overactive quality department and inspecting quality into the components they produce. Their efforts to reach quality objectives by these very unproductive means may lead to what appear, at first glance, to be rather unintuitive results.

Additional studies in other industries can help determine whether satisfaction determinants are industry-specific or whether there is a "universal" set of quality management and supplier development practices that lead to mutual buyer/supplier contentment and to supplier quality performance. Despite the great strides made in improving product quality, it appears that much work remains to be done further up the supply chain where the foundations of form, fit, and function are laid.

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