An empirical analysis of the competitive dimensions of quality performance in the automotive supply industry

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Abstract *This paper examines the competitive dimensions of quality for first tier suppliers in the automotive industry. A theoretically relevant set of quality variables is identified from the literature. The results of a factor analysis show that quality is a two dimensional construct in the automotive supply industry. The core dimensions of quality are: product quality, which is primarily focused on design superiority and performance of the physical product; and service quality, which comprises both pre- and post-sale service. The study reveals that both product quality and service quality are related to overall firm performance, regardless of whether asset based, investment based, or market based measures are used.*

Introduction

Intense global competition has highlighted the increasing importance of quality (Lawrence, 1980; Schonberger, 1982). Superior quality no longer differentiates competitors; instead, it validates a company's worthiness to compete (Giffi *et al.*, 1990). Once recognized as an order-winner, high product quality is now considered an order-qualifier (Handfield and Ghosh, 1994).

In the operations literature, quality is often treated as multi-dimensional in nature. For example, Garvin (1987) identified eight dimensions of quality that can be used individually or collectively to obtain a competitive advantage. In contrast, Sinha and Willborn (1985) framed the concept of quality in life cycle terms, focusing on three stages – conformance, performance, and design – where contributions to product quality are made and evaluated. More recently, Madu *et al.* (1995) examined three dimensions of quality (customer satisfaction, employee satisfaction, and employee service quality) in relationship to organizational performance. Other scholars have routinely made distinctions between different aspects of quality performance, such as product reliability, product durability, and conformance to specifications (e.g. Krajewski and Ritzman, 1996). While the literature suggests that quality is a multi-dimensional construct, the empirical evidence supporting this claim is scant.

The purpose of this research is two-fold. First, we examine empirically the dimensions of quality in the automotive supply industry. The dimensionality of

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quality performance is explored in a single industry study of first tier suppliers to the Big 3 automakers (General Motors, Ford, Chrysler) in North America. A single industry study was deemed appropriate for two major reasons:

(1) The dimensions of quality may differ in number or identity from one industry to another.

(2) A single industry study allows researchers to reduce variability (e.g. industry effects).

The second purpose of the research is to establish the predictive validity of the quality dimensions identified in this study by examining their relationship with overall firm performance. We examine asset based, investment based, and market based measures of firm performance.

This paper is organized as follows. First, the strategic operations literature is reviewed to develop a theoretically relevant set of quality variables. The methodology is then described, including the sampling procedure and measurement process. The set of quality variables is then factor analyzed to identify the core dimensions of quality in the automotive supply industry. The reliability of these quality constructs are also examined. Next, we examine the relationships between the core dimensions of quality and six measures of overall firm performance. Finally, the managerial implications of this study are presented along with suggestions for future research.

A review of the literature

The multi-dimensional nature of quality

Researchers and practitioners from philosophy, economics, marketing, and operations management have differing viewpoints concerning quality. For example, definitions of quality provided by engineering, marketing, and manufacturing scholars are often conflicting. Forker (1991) observed that these varying perspectives could be classified into five major categories of quality approaches: transcendent; product-based; user-based; manufacturing-based; and value-based. The transcendent approach equates quality with "innate excellence" and claims that although quality is difficult to define, it is absolute and is identifiable through experience. The product-based approach, which derives from economics, defines quality as a sum or weighted sum of amounts of desired attributes in a product. The user-based approach identifies a "high quality" item as one that best satisfies consumer needs or wants. The manufacturing-based approach equates quality with conformance to specifications. Lastly, the value-based approach defines quality as a measure of not only the product's conformance to specifications or performance at an intended level, but also its conformance/performance at an acceptable cost or price.

Garvin (1984b, 1987, and 1988) identified eight "competitive dimensions of quality" that could guide a firm in its use of quality as a competitive weapon.

While his quality dimensions were the result of subjective impressions and anecdotal evidence, they have been well-received and his work is considered seminal in the strategic management area. Garvin's eight dimensions are:

(1) performance;

(2) features;

(3) reliability;

(4) conformance;

(5) durability;

(6) serviceability;

(7) aesthetics; and

(8) perceived quality.

He contended that by focusing on a combination of these dimensions, and outperforming competitors along these dimensions, a firm could effectively differentiate its product offerings.

Each of Garvin's dimensions is linked to one of the quality approaches discussed earlier. Performance and features are yardsticks for the technological advantages of a product which the product-based approach to quality emphasizes. Reliability and conformance gauge a product's adherence to specifications – the focus of the manufacturing-based approach to quality. Durability and serviceability appraise a product's expected performance in terms of the time- and cost-based value the product delivers (i.e. the value-based approach to quality). Lastly, aesthetics and perceived quality represent consumer judgments about the superiority of a product, which the transcendent and user-based approaches deem essential in describing quality.

Other scholars frame the quality concept in terms of a product's life cycle (Sinha and Willborn, 1985). For example, design, conformance, and performance are used to identify stages where contributions to product quality are made and evaluated. Quality of design begins with research by marketing personnel into customer requirements regarding the attributes and performance customers expect from a particular product or service. Next, customer requirements are translated by design engineers into product and process specifications. Quality of design is then determined by how well the resulting specifications meet consumer expectations as measured by customer satisfaction surveys and sales/service call analyses. Quality of conformance

measures the degree to which manufactured products and delivered services do what they are supposed to do. The third dimension, quality of product performance, is established once the product leaves the manufacturer and the consumer uses and evaluates it.

Two major aspects of quality are identified in a conceptual model developed by Maani and Sluti (1990): a manufacturing-based definition (e.g. conformance quality); and a product-based definition (e.g. design quality). They argue that the link between quality and business unit performance may be explained by two distinct paths arising from these two different definitions of quality.

While many scholars suggest that quality is multi-dimensional, limited empirical evidence exists to support this contention. Safizadeh *et al.* (1996) cross industry empirical analysis of the product-process matrix applied factor analysis to reduce 13 competitive priorities to six manufacturing performance factors (i.e. quality, time, cost, product flexibility, development speed, and volume flexibility). Four of Garvin's eight quality dimensions were addressed by items in their research survey:

(1) product performance;

(2) number of features;

(3) conformance; and

(4) perceived quality.

All four of these items loaded on a single quality factor.

An earlier study by Roth and Miller (1990) also examined dimensions of manufacturing performance in a cross industry setting. Factor analysis was used to reduce 11 competitive capabilities to five independent dimensions. Two of the 11 items were quality-related: consistent quality (reliability); and high-performance products. Both of these items loaded together. Note, however, that the sets of items examined in this study as well as the study by Safizadeh *et al.* (1996) were not comprehensive. While Roth and Miller (1990) considered only two of Garvin's eight quality dimensions, Safizadeh *et al.* (1996) failed to include product reliability, product durability, and serviceability.

More recently, Vickery *et al.*'s (1997) furniture industry study used factor analysis to reduce ten competitive priorities to four dimensions of manufacturing strength: delivery; value; flexibility; and innovation. Three quality items were considered in their research: product reliability; conformance quality; and design/innovation quality. Product reliability and conformance quality loaded together with low manufacturing cost on the "value" factor while design quality loaded with new product introduction on the "innovation" factor. In this case also, the set of quality items examined was not comprehensive.

Another recent study by Madu *et al.* (1995, 1996) treated quality as multi-dimensional. Their study examined whether there is a causal relationship between multivariate constructs of quality and organizational performance. The three constructs were (with items in parentheses):

(1) Customer satisfaction (price, services, product features, product reliability, company culture, and overall customer satisfaction).

(2) Employee satisfaction (politics, absenteeism, leadership, financial rewards, turnover rate, nonfinancial rewards, performance evaluation, training and educational programs, promotion, job enrichment opportunities, and overall employee satisfaction).

(3) Employee service quality (availability, responsiveness, timeliness, completeness, and pleasantness).

Clearly, these three factors are completely different from the quality related factors identified by Safizadeh *et al.* (1996), Roth and Miller (1990), and Vickery *et al.* (1997).

The focus of the study

The set of quality performance variables defined for our study is based on previous research (Garvin, 1987, Forker *et al.*, 1996) and discussions with an expert panel of automotive industry executives from the Automotive Industry Action Group (AIAG) in Southfield, Michigan. The input of these experts ensured that our set of quality dimensions was comprehensive and meaningful within the automotive industry. The dimensions of quality used for this study are listed and defined in Table I.

Quality dimension	Description
Product reliability	The ability to maximize the time to product failure or malfunction
Product durability	The ability to maximize the time to product replacement
Conformance to specifications	The ability to manufacture a product whose operating characteristics meet established performance standards
Design quality	The ability to provide a product with capabilities, features, styling, and/or operating characteristics that are either superior to those of competing products or unavailable with competing products
Pre-sale customer service	The ability to service the customer during the purchase decision process (that is, before the customer buys the product)
Product support	The ability to service the customer in providing product support after the sale of the product to ensure continuing satisfaction
Responsiveness to customers	The ability to respond in a timely manner to the needs and wants of the company's customers including potential customers

Table I.
Competitive quality items

Note that product reliability, product durability, and conformance to specifications are taken directly from Garvin's seminal work. Design quality incorporates Garvin's performance, features, and aesthetic dimensions according to Forker *et al.* (1996). Garvin's serviceability dimension was revised to consider pre-sale customer service and product support (after-sale service) separately. This revision was recommended by our panel of automotive industry experts. Note that Madu *et al.* (1995, 1996) also focus on service quality. A new quality-oriented performance variable, arising from total quality management's emphasis on "closeness to the customer", is also examined – responsiveness to customers. This service-oriented variable assesses the ability of a company to respond in a timely manner to the needs and wants of its customers, including potential customers.

Unlike Madu *et al.* (1995, 1996), we do not consider "customer satisfaction" or "employee satisfaction" to be quality variables *per se*. Customer satisfaction is an outcome of quality performance rather than a dimension of quality performance. This view of customer satisfaction is consistent with the considerable body of marketing literature devoted to this topic (see for example Anderson and Sullivan, 1993; Anderson *et al.,* 1994; Leuthesser and Kohli, 1995). A similar argument can be made with respect to employee satisfaction (i.e. job satisfaction). Employee satisfaction has its roots in the organizational behavior literature dating back to the 1960s, entirely independent of a quality performance context. Over 3,500 articles on job satisfaction have been published since then (Silberstang, 1995). While employee satisfaction may affect quality performance, it is not a quality performance variable *per se.*

Quality performance and overall firm performance

For many years, empirical studies examining quality and business performance focused on the Profit Impact of Marketing Strategies (PIMS) database (Buzzell and Wiersema, 1981a, 1981b; Craig and Douglas, 1982; Phillips *et al.,* 1983; Schoeffler *et al.*, 1984). Using PIMS data, researchers found a strong positive relationship between quality and market share. High product quality was also associated with increases in cumulative production and subsequent reductions in manufacturing cost due to learning curve effects. PIMS studies have also found a strong positive correlation between quality and financial measures of profitability such as ROI, independent of market share.

More recently, the contribution of eight different quality variables to overall business performance was examined in the furniture industry (Forker *et al.*, 1996). The results of this study were mixed. Conformance quality was significantly related to ROI growth, sales growth, and ROS growth. Reliability was significantly related to ROA after-tax. Product durability was significantly related to ROA after-tax, ROI growth, and ROS. Design quality and product improvement were both related to ROI, ROI growth, and sales growth. Design quality was additionally related to ROS, and product improvement was also related to ROS growth. Company reputation was related to market share, ROS and ROS growth, and customer service was related to ROI growth. This

research was significant in identifying potentially promising relationships between performance on various quality attributes and business performance in the furniture industry.

Another study found a significant causal relationship between three quality-related constructs (customer satisfaction, employee satisfaction, and employee service quality) and organizational performance (Madu *et al.*, 1995; Madu *et al.,* 1996). The presence of such relationships, as well as the identification of key indicators within each construct for different types of firms, were explored based on the perceptions of middle managers in Taiwan and the USA. However, the relationships were different for the four types of firms based on age and size. Also, within the same firm types, there were differences among countries. For older firms, Taiwanese managers perceived customer satisfaction as the most important for improving organizational performance, while US managers tended to perceive employee satisfaction as the most important. For younger firms, US managers perceived customer satisfaction as influencing organizational performance, while Taiwanese managers perceived both customer satisfaction and employee satisfaction as doing so.

Summary

From a review of the literature on quality and discussion with industry experts, the seven competitive quality items in Table I were identified. Our first goal is to determine which of these can be grouped together as reflecting core underlying dimensions of quality performance. For example, the literature suggests that reliability and durability (and possibly conformance) form a set. Also, pre-sale customer service and product support may be related because the latter is really a type of post-sale customer service. The literature also supports a relationship between quality and firm performance. The key question here is whether quality requires such high investment that a positive relationship will not be evident in financial performance measures such as ROI but could be evident in market-based measures such as market share. We examine the quality-performance relationships using factor score regression.

Research methodology

The sampling procedure

The sampling frame consisted of the top 150 (in terms of annual sales) independently owned first tier suppliers to the Big 3 automakers (i.e. General Motors, Ford, and Chrysler) in North America. The unit of analysis is the strategic business unit (SBU). This population was identified with the assistance of a panel of experts from the Automotive Industry Action Group (AIAG). AIAG is a professional association with over 1,000 members including automakers such as General Motors, Ford, and Chrysler. The reason for selecting these 150 suppliers was because they account for over 90 per cent of the purchasing sales volume by the automakers in North America. The automotive industry was selected because of its historic as well as recent emphasis on quality as a key competitive weapon. The study focuses on first

tier suppliers because they are more likely than lower tier suppliers to be actively engaged in strategic quality initiatives. Under the provisions of QS-9000 (Eastman, 1995), the Big 3 are requiring their first tier suppliers to upgrade their competitive quality programs and methods. Among first tier suppliers there exists variety in products, process types and technologies, as well as competition for Big 3 business.

A key advantage of a single industry study such as this one is that some variance owing to industry specific conditions can be controlled. For example, quality dimensions may differ across industries in number, identity, and relative strategic importance. Industries are also affected by the business cycle which impacts performance. Controlling for industry effects can compensate for variability between industries, in terms of work force management, competitive forces, union policies, etc. Controlling for these industry specific differences means that firm specific variance is highlighted in all subsequent analyses and relationships are not unduly masked because of inflated error variance (Flynn *et al.*, 1990). The major drawback of a single industry study is reduced external validity. However, a profile of the first tier automotive suppliers reveals some degree of diversity as mentioned earlier. For example, our sample includes manufacturers of seating systems and manufacturers of anti-lock braking systems. Thus, external validity is not as severely compromised by focusing on this industry as compared with focusing on a more homogenous industry group.

We targeted chief executive officers (CEOs) to serve as respondents in this study. Research suggests that greater attention to informant selection can help to overcome the common method variance problem when practical considerations require single respondents (Miller and Roth, 1994). Phillips (1981) indicates that high ranking informants tend to be more reliable sources of information than their lower ranking counterparts. We targeted people at the CEO level to assure that the respondents were knowledgeable of strategic quality issues and the performance of their companies relative to their competitors. The CEOs were mailed research questionnaires accompanied by explanatory letters; subsequently, repeated follow-up telephone calls were used. CEOs of multiple business units were instructed to select one of their SBUs and to forward the research questionnaire. We requested that the questionnaire be completed by the CEO or director of an SBU which is a first tier supplier to a North American original equipment manufacturer (OEM). North America includes Mexico, Canada, and the USA.

Description of the sample

The final sample for the study consisted of 57 of the 150 firms contacted, for a response rate of approximately 38 per cent. Mean annual sales were $501,516,415 with a standard deviation of 637,456,698. The mean number of employees was 2,810 with a standard deviation of 3,431. The mean percentage of sales which were direct sales to North American OEMs was 83.67 per cent.

Since the questionnaires were not distributed anonymously, all of the nonrespondents were identified and all of them were willing to answer a few questions on the telephone. The most often cited reason for not completing the questionnaire was a lack of time. The second most prevalent reason was that company policy did not allow them to complete questionnaires because of concerns for confidentiality. To ensure that the respondent sample was not biased towards specific types of firms, responding firms and nonresponding firms are compared or, as a proxy, early versus late respondents are compared (Armstrong and Overton, 1977). A *t*-test was used to assess the statistical significance of the sample means between the early (first 29 questionnaires received) and late (last 28 questionnaires received) responses. To determine whether the early versus late response groups are different, a *t*-statistic was calculated for all the variables used in the study. No statistically significant differences were found for any of the variables used in the study at $\propto = 0.05$. Therefore, this evidence of lack of nonresponse bias, while limited, does enhance the generalizability of the results to the larger population.

Validation of the questionnaire

The AIAG expert panel assisted in the identification and validation of the constructs and variables in our study. In addition, the panel assisted in pre-testing the survey instrument. The final research questionnaire was validated for comprehension and completeness in advance through interviews with AIAG experts. One member of the research team also shared insights based on seven years of experience in the automotive industry. In the interest of face validity, all items appearing on the research questionnaire were defined. The expert panel reviewed the definitions of terms and recommended changes to ensure that there were no items with ambiguous or multiple interpretations.

Measures of quality

Quality performance was measured by having the respondents rate their firm's performance on each of the seven quality items listed in Table I. The respondents were asked to indicate on seven point, "poor" (= 1) to "excellent" (= 7) scales their firm's performance relative to its major competitors. A seven point Likert-type scale was used instead of a five point scale to alleviate the problem of attenuation due to restriction of range. Nemetz (1990) found that attenuation affected perceptual data on quality and, to a lesser extent, other competitive dimensions (e.g. cost, flexibility, time). Attenuation due to restriction of range weakens correlations when variation in the data is small. Several studies show that improved reliability is achieved by increasing scale points to seven but there is no marginal improvement beyond seven (Komorita and Graham, 1965; Lissitz and Green, 1975; Cicchetti *et al.,* 1985).

Measures of business performance

Business performance was evaluated using a set of six fairly standard business performance measures: pre-tax return on assets (pre-tax ROA); after-tax return

on assets (after-tax ROA); return on investment (ROI); growth in return on investment (ROI growth); market share in the North American automotive industry; and growth in market share. Performance relative to each of the measures was assessed in two ways:

(1) A *subjective* assessment, i.e. the SBU's performance relative to its major industry competitors was assessed by the respondent on a seven point Likert-type scale with endpoints "worst in industry" (= 1) and "best in industry" (= 7).

(2) An *objective* assessment, i.e. actual values for each of the non-growth focused measures were obtained from respondents willing to disclose such information. These were used to calculate objective measures for the two growth measures.

The correlations of the subjective versus the actual ratings are presented in Table II. All correlations were significant: ROI at the 0.10 level, and the rest at < 0.05. For example, the correlation between the subjective rating and the actual objective value for after-tax return on assets was 0.646 with a p-value of 0.00045. Past research has also found that managerial assessments are

Performance measure	n	Mean	Correlation of A and B
Pre-tax ROA			
A: Subjective rating	52	4.904	
B: Actual value	27	18.737	0.611*
After-tax ROA			
A: Subjective rating	52	4.962	
B: Actual value	23	12.352	0.646*
ROI			
A: Subjective rating	51	5.078	
B: Actual value	23	25.644	0.314***
Growth in ROI			
A: Subjective rating	53	4.528	
B: Actual value	23	–0.143	0.689*
Market share			
A: Subjective rating	52	4.85	
B: Actual value	32	24.703	0.487*
Growth in market share			
A: Subjective rating	55	4.818	
B: Actual value	31	0.0753	0.338**

Notes: * Significant at the 0.01 level; ** Significant at the 0.05 level; *** Significant at the 0.10 level.

Table II.
Means and correlations of the business performance measures

Quality variables	Mean	Standard deviation	Minimum value	Maximum value
Conformance to specifications	5.947	0.915	4	7
Pre-sale customer service	5.474	1.020	3	7
Design quality	5.579	1.068	2	7
Product durability	5.754	1.023	4	7
Product reliability	5.877	0.908	4	7
Product support	5.614	1.082	3	7
Responsiveness to customers	5.393	1.039	3	7

Note: Scale was 1 to 7; quality performance relative to major competitiors – "poor" = 1 and "excellent" = 7

Table III.
Descriptive statistics for the quality ratings

consistent with objective internal performance and even with external secondary data (Dess and Robinson, 1984; Venkatraman and Ramanujam, 1986; Vickery *et al.*, 1994).

Note that the sample sizes for the actual values were much smaller than those for the subjective measures due to the unwillingness of many CEOs to release financial information. Since the subjective ratings were highly positively correlated with the actual values, the subjective ratings were used in all subsequent analyses to take advantage of the larger sample sizes. Larger sample sizes provide some assurance that statistical nonsignificance does not occur only because the sample sizes are too small.

Results

Analysis of descriptive statistics

The mean quality ratings were all greater than 5 (see Table III). Listed in descending rank order, they are:

Quality variables	Factor 1	Factor 2
Product reliability	0.870	0.109
Product durability	0.834	–0.022
Conformance to specifications	0.556	0.502
Design quality	0.506	0.144
Pre-sale customer service	–0.012	0.813
Product support	0.530	0.634
Responsiveness to customers	0.120	0.862
Eigenvalue	3.067	1.335
Proportion of variance explained	43.81	19.08
Cumulative variance explained	43.81	62.88
Name given	Product quality	Service quality

Table IV.
Factor analysis of the quality ratings: two factor solution with varimax rotation

(1) conformance to specifications;

(2) product reliability;

(3) product durability;

(4) product support;

(5) design quality;

(6) pre-sale customer service; and

(7) responsiveness to customers.

It is not surprising that conformance quality and product reliability are highly ranked. These appear as the number 1 and number 3 ranked competitive priorities for US and European firms in the 1994 Manufacturing Futures cross industry survey, and as the number 1 and number 2 ranked competitive priorities in the 1996 Manufacturing Futures survey (Kim, 1996).

Factor analysis

Using the performance ratings on the seven quality items, a principal components factor analysis with varimax rotation was performed. Two factors were retained (as shown in Table IV) for the following reasons. First, both factors in the two factor solution generated an eigenvalue greater than 1.0. Second, the two factor solution explained more than 50 per cent of the variance while subsequent solutions added little marginally to the cumulative variance explained. Lastly, the rotated factor pattern for the two factor solution was "clean" (Lissitz and Green, 1975) for the most part. With the exception of conformance to specifications and product support, the loading on each core dimension of quality was over 0.50, and all other off factor loadings were below 0.50. Note, however, that conformance to specifications did load definitively on Factor 1 while barely clearing the cut-off value for Factor 2. Also, product support exhibited a much higher loading on Factor 2 than on Factor 1. Finally, the two factor solution was easily interpretable and supported by the literature.

The first factor consists of design quality, conformance to specifications, product durability, and product reliability. This factor is interpreted to represent product quality since it is primarily concerned with the design of the physical product and the product performance it engenders (Sahin and Polatoglu, 1996). In the automotive supply industry, these four items are typically the responsibility of design engineering and manufacturing. Design quality, conformance to specifications, product durability, and product

reliability are all dimensions of quality that are scrutinized, measured, evaluated, and established during new product development and commercialization.

The second factor consists of customer service (pre-sale), product support (post-sale customer service), and responsiveness to customers. This factor is interpreted to represent service quality. Once the product is designed with the customer in mind, the service quality dimension comes into play. Service quality is distinct from the quality of the physical product, but is intimately related to the quality of the total product package. Giffi *et al.* (1990) contend that product quality and service quality are becoming intermingled in consumers' minds and it will soon be impossible for a product to be judged as high quality if the service and support structures are not of equal stature.

The items comprising each factor in Table IV were analyzed separately to verify unidimensionality. Reliability analyses were conducted using Cronbach standardized alphas. The Cronbach alpha for Factor 1 (product quality) was 0.708; the Cronbach alpha for Factor 2 (service quality) was 0.742. These analyses strongly supported the unidimensionality and reliability, respectively, of our two quality constructs.

Table V.
Standardized scoring coefficients

Quality variables	Standardized scoring coefficients Factor 1 Product	 Factor 2 Service
Product reliability	0.421	–0.121
Product durability	0.430	–0.187
Conformance to specifications	0.179	0.167
Design quality	0.228	–0.025
Pre-sale customer service	–0.176	0.461
Product support	0.138	0.247
Responsiveness to customers	–0.120	0.461

Table VI.
Results of the regression analyses

Dependent variable: Business performance	R^2	*p*-value	Independent variables Beta weights (*p*-values) Factor 1: product	 Factor 2: service
Pre-tax ROA	0.145	0.022	0.412 (0.027)	0.303 (0.099)
After-tax ROA	0.147	0.020	0.377 (0.033)	0.315 (0.072)
ROI	0.192	0.006	0.472 (0.008)	0.314 (0.067)
Growth in ROI	0.100	0.071	0.234 (0.211)	0.356 (0.056)
Market share	0.130	0.034	0.358 (0.076)	0.389 (0.055)
Growth in market share	0.122	0.034	0.325 (0.071)	0.339 (0.057)

Factor score regression analysis

The standardized scoring coefficients for the two factor solution were determined (see Table V) and these scores were used as the weights in calculating each firm's scores on the two factors. From the standardized scoring coefficients, it can be seen that product reliability and durability are the primary (and about equal) contributors to the product factor; these are followed by design quality and conformance. Of the three service items, only product support has a positive scoring coefficient on the product factor. As for the service factor, pre-sale customer service and responsiveness to customers receive the greatest weights and are about equal. This is followed by product support. Of the product items, only the conformance weighting is positive on the service factor.

The predictive validity of the core dimensions of quality was examined by modeling the two quality factors as independent variables in a series of regression analyses. Six regression analyses were performed, one for each of the overall firm performance measures (e.g. ROI). The results are in Table VI, which lists the model R_2, p-value, and the beta weights (with their associated p-values) for each of the two factors. As far as the significance of the overall models is concerned, five of the six are significant at less than the 0.05 level; namely, ROI ($R_2 = 0.192$), pre-tax ROA ($R_2 = 0.145$), after-tax ROA ($R_2 = 0.147$), market share ($R_2 = 0.130$), and growth in market share ($R_2 = 0.130$). The model for ROI growth was significant at the 0.10 level.

Another way of analyzing the results is to examine whether one of the factors is a more consistently significant predictor of business performance measures. However, both product quality (Factor 1) and service quality (Factor 2) clearly stand out as areas of strength. Product quality is significant at 0.10 or less in every one of the six models except growth in ROI. Service quality is significant in all six models.

Summary and discussion

The dimensions of quality

In this study, the literature and an expert panel were used to identify and define seven competitive dimensions of quality. A factor analysis of these items provides empirical support for quality as two-dimensional. Specifically, the two core dimensions of quality identified were:

(1) Product quality, consisting of design quality (including number of features, product performance, etc.), conformance to specifications, product durability, and product reliability.

(2) Service quality consisting of pre-sale customer service, product support (post-sale customer service), and responsiveness to customers.

Our results support neither the life cycle model (Sinha and Willborn, 1985) nor the conceptual model developed by Maani and Sluti (1990). First, the life cycle

model would suggest that design and conformance should load on different factors, and possibly even that pre-sale customer service should be differentiated from post-sale customer service (or product support). Design and conformance are different life stages from the manufacturer's point of view; pre- versus post-sale customer service are different stages from the customer's point of view, hence requiring different manufacturer approaches. Our results provide no support for life cycle analysis since different life stages loaded on the product and on the service factors. Neither did the items load in a way to support a manufacturing versus product distinction (Maani and Sluti, 1990), since conformance and design loaded together.

The results also suggest that the core dimensions of quality may be fewer than some authors have suggested. For example, Garvin (1987) distinguishes between reliability, durability, and conformance. Our results do not support such a distinction since these three loaded together on the product factor. Rather, our results distinguish product versus service quality in the automotive supply industry. This result is consistent with Safizadeh *et al.* (1996) and Roth and Miller's (1990) single quality factors since all of Roth and Miller's (1990) quality items were product-related, and three of Safizadeh *et al.* (1996) four quality items were product related (none were service-related). This result appears inconsistent with Vickery *et al.* (1997). In their furniture industry study, product reliability and conformance quality loaded together with low manufacturing cost, while design quality loaded with new product introduction. However, in our automotive study, design quality barely made the cut-off (0.50) for the product quality factor, indicating that it could split off from this factor to load with other items if a comprehensive set of competitive items was analyzed.

The factor analysis results of our study have interesting implications for the design engineering, marketing, and manufacturing interface. The literature suggests (see e.g. Vickery *et al.*, 1994) that design engineering and manufacturing have primary responsibility for Factor 1 (product quality). Of course, marketing may also play a role, especially in conjunction with design. On the other hand, manufacturing and marketing appear to share responsibility for Factor 2 (service quality), especially with respect to product support and responsiveness to customers (Chase and Garvin, 1989). In other words, manufacturing responsibility spans both factors but it is shared responsibility in each case. Thus, effective integration of manufacturing, design engineering and marketing appears to be critically important in engendering both product quality and service quality. The design/manufacturing interface to engender product quality has been addressed by methods such as: design for manufacturability; design for assembly; and concurrent engineering. Methods addressing the effective integration of marketing and manufacturing for the purpose of facilitating service quality are potentially fruitful areas for research. Indeed, few studies have even examined the division of responsibility for quality among the functional areas of the firm.

While our results are generally consistent with Safizadeh *et al.* (1996) and Roth and Miller's (1990) cross industry studies, it should be noted that it is possible for industry differences to have an impact on the nature of the underlying quality dimensions. These differences can yield a different number of factors and a different composition of items (even if the same number of factors is found). Clearly, in the so-called "service" industries, such as banking, researchers can expect a different quality structure. However, even in manufacturing sectors, differences may be found. For example, in industries where new product churning is the norm, design and innovation quality may emerge as a separate factor. Computers is an example of such an industry.

Predicting firm performance

The literature suggests that performance along the competitive dimensions of quality contributes to overall firm performance and ultimately to competitive advantage (Forker *et al.*, 1996; Garvin, 1987). Our results support this contention. All six of our measures of overall firm performance are significantly predicted by regression models having product and service quality as independent variables. More importantly, these findings support the predictive validity of the core dimensions of quality identified in our study.

The six regression results show that the betas for product quality and for service quality are all positive and significant, with the one exception of the product beta for ROI growth. In other words, product quality and service quality are generally positive contributors to business performance, regardless of whether asset based, investment based or market share based measures of business performance are used. We found no evidence that quality in product or service costs so much that, while market based firm performance may be enhanced, ROI or ROA based firm performance suffers. Clearly, our results support the contention that "quality pays", at least in this industry. More specifically, both product and service quality pay across the firm performance spectrum for these suppliers to automotive OEMs.

It should be noted, however, that the trend toward fewer, preferred suppliers (and close partnerships with those remaining) may mean that the value of service quality is enhanced in this setting as compared to other industries. Where intense competition on price among numerous, largely undifferentiated suppliers is the norm, service quality may not contribute much to firm performance. But if products are largely undifferentiated, one could also argue that superior service quality is the only avenue other than price for competitive advantage. Thus, firms who manage to deliver superior service quality may enjoy superior firm performance, at least in market share based measures. The role of service quality as a differentiator and the differences in the relationship between service quality and firm performance across industry types remain important areas for future research.

Since this was a single industry study, we assumed that the regression results would not be mediated or moderated by environmental uncertainty, competitive intensity, or industry munificence. Thus, we did not control for

these factors nor did we conduct the corresponding subgroup analyses. Certainly, if quality research is to move towards an overarching theoretical model, both firm level and industry level environmental characteristics will have to be taken into account. Additional factors may include firm size (for example, as measured relative to the largest customer) since size is associated with the specialization and formalization inherent in the establishment of a separate quality department (Blauw and During, 1990) and channel power. Other factors such as employee satisfaction (Kuei and Madu, 1995) may have an impact on product or service quality performance as antecedents rather than moderators or mediators. These latter factors would be important in models of quality management practices and processes in particular, because they result in the quality outputs that were the focus of this paper.

References

Anderson, E.W. and Sullivan, M.W. (1993), "The antecedents and consequences of customer satisfaction for firms", *Marketing Science*, Vol. 12 No. 2, pp. 126-43.

Anderson, E.W., Fornell, C. and Lehmann, D.R. (1994), "Customer satisfaction, market share, and profitability: findings from Sweden", *Journal of Marketing*, Vol. 58, pp. 53-66.

Armstrong, J.S. and Overton, T.S. (1977), "Estimating nonresponse bias in mail surveys", *Journal of Marketing Research*, Vol. 14, August, pp. 396-402.

Blauw, J.N. and During, W.E. (1990), "Adoption of an organizational innovation: total quality control in industrial firms", *International Journal of Production Research*, Vol. 28 No. 10, pp. 1831-46.

Buzzell, R.D. and Wiersema, F.D. (1981a), "Modeling changes in market share: a cross-sectional analysis", *Strategic Management Journal*, Vol. 2 No. 1, pp. 27-42.

Buzzell, R.D. and Wiersema, F.D. (1981b), "Successful share-building strategies", *Harvard Business Review*, Vol. 59 No. 1, pp. 135-44.

Chase, R.B. and Garvin, D.A. (1989), "The service factory", *Harvard Business Review*, July-August, pp. 61-9.

Cicchetti, D.V., Showalter, D. and Tyrer, P.J. (1985), "The effect of number of rating scale categories on levels of interrater reliability: a Monte Carlo simulation", *Applied Psychological Measurement*, Vol. 9 No. 1, pp. 31-6.

Craig, C.S. and Douglas, S.P. (1982), "Strategic factors associated with market and financial performance", *Quarterly Review of Economics and Business*, Vol. 22 No. 2, pp. 101-11.

Dess, G.S. and Robinson, R.B. (1984), "Measuring organizational performance in the absence of objective measures", *Strategic Management Research*, Vol. 5 No. 3, pp. 265-73.

Eastman, M. (1995), "The common code", *Cutting Tool Engineering*, pp. 22-8.

Flynn, B.B., Sakakibara, S., Schroeder, R.G., Bates, K.A. and Flynn, E.J. (1990), "Empirical research methods in operations management", *Journal of Operations Management*, Vol. 9 No. 2, pp. 250-84.

Forker, L.B. (1991), "Quality: American, Japanese, and Soviet perspectives", *Academy of Management Executive*, Vol. 5 No. 4, pp. 63-74.

Forker, L.B., Vickery, S.K. and Droge, C.L (1996), "The contribution of quality to business performance", *International Journal of Operations & Production Management*, Vol. 16 No. 8, pp. 44-62.

Garvin, D.A. (1984b), "What does 'product quality' really mean?", *Sloan Management Review*, Vol. 26 No. 1, pp. 25-43.

Garvin, D.A. (1987), "Competing on the eight dimensions of quality", *Harvard Business Review*, Vol. 65 No. 6, pp. 101-9.

Garvin, D.A. (1988), *Managing Quality*, The Free Press, New York, NY.

Giffi, C., Roth, A.V. and Seal, G.M. (1990), *Competing in World Class Manufacturing*, Business One Irwin, Homewood, IL, p. 329.

Handfield, R.B. and Ghosh, S. (1994), "Creating a quality culture through organizational change: a case analysis", *Journal of International Marketing*, Vol. 2 No. 3, pp. 7-36.

Kim, J.S. (1996), *Search for a New Manufacturing Paradigm*, Executive Summary of the 1996 Manufacturing Futures Survey Research Report Series, Boston University Manufacturing Roundtable, October, p. 12.

Komorita, S.S. and Graham, W.K. (1965), "Number of scale points and the reliability of scales", *Educational and Psychological Measurement*, Vol. 4, pp. 987-95.

Krajewski, L.J. and Ritzman, L.P. (1996), *Operations Management: Strategy and Analysis*, Addison-Wesley, New York, NY.

Kuei, C. and Madu, C.N. (1995), "Managers' perceptions of factors associated with quality dimensions for the different types of firms", *Journal of Quality Management*, pp. 67-80.

Lawrence, P. (1980), *Managers and Management in West Germany*, St. Martin's Press, New York, NY.

Leuthesser, L. and Kohli, A.K. (1995), "Relational behavior in business markets: implications for relationship management", *Journal of Business Research*, Vol. 34, pp. 221-33.

Lissitz, R.W. and Green, S.B. (1975), "Effect of the number of scale points on reliability: a Monte Carlo approach", *Journal of Applied Psychology*, Vol. 60 No. 1, pp. 10-13.

Maani, I.E. and Sluti, D.G. (1990), "A conformance-performance model: linking quality strategies to business units' performance", in Ettlie, J.E., Burstein, M.C. and Fiegenbaum, A. (Eds), *Manufacturing Strategy, The Research Agenda for the Next Decade*, Proceedings of the Joint Industry University Conference on Manufacturing Strategy, Ann Arbor, MI, pp. 85-96.

Madu, C.N., Kuei, C-H. and Jacob, R. (1996), "An empirical assessment of the influence of quality dimensions on organizational performance", *International Journal of Production Research*, Vol. 34, pp. 1943-62.

Madu, C.N., Kuei, C-H. and Lin, C-H. (1995), "A comparative analysis of the practice of quality in Taiwan and the US", *Decision Sciences*, Vol. 26 No. 5, pp. 621-35.

Miller, J.G. and Roth, A.V. (1994), "A taxonomy of manufacturing strategies", *Management Science*, Vol. 40 No. 3, pp. 285-304.

Nemetz, P.L. (1990), "Bridging the strategic outcome measurement gap, in manufacturing organizations, in manufacturing strategy: the research agenda for the next decade", in Ettlie, J.E., Burstein, M.C. and Fiegenbaum, A. (Eds), *Manufacturing Strategy, The Research Agenda for the Next Decade*, Proceedings of the Joint Industry University Conference on Manufacturing Strategy, Ann Arbor, MI, pp. 63-74.

Phillips, L.W. (1981), "Assessing measurement error in key informant reports: a methodological note on organizational analysis in marketing", *Journal of Marketing Research*, Vol. 18, pp. 395-415.

Phillips, L.W., Chang, D.R. and Buzzell, R.D. (1983), "Product quality, cost position, and business performance: a test of some key hypotheses", *Journal of Marketing*, Vol. 37, pp. 26-43.

Roth, A.V. and Miller, J.G. (1990), "Manufacturing strategy, manufacturing strength, managerial success, and economic outcomes", in Ettlie, J.E., Burstein, M.C. and Fiegenbaum, A. (Eds), *Manufacturing Strategy, The Research Agenda for the Next Decade*, Proceedings of the Joint Industry University Conference on Manufacturing Strategy, Ann Arbor, MIn, pp. 97-108.