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BEYOND PROCESS: TQM CONTENT AND FIRM PERFORMANCE

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Authors of the literature on total quality management (TQM) have been much more concerned with process than content. This article considers TQM in relation to firm orientation and identifies market advantage, product design efficiency, process efficiency, and product reliability as the key features of its content. Performance expectations for TQM, in the form of increased revenues, reduced costs, and their time lags, are addressed in the context of environmental uncertainty.

Although the emergence of quality as a management issue can be attributed to work done at Western Electric in the 1920s, the real catalyst for growth in the quality movement was the U.S. Department of Defense, which, early in the Second World War, decided to accept (reject) the delivery of munitions on the basis of a quality sampling procedure (Garvin, 1988). During the next 20 years, Philip B. Crosby, W. Edwards Deming, Armand V. Fiegenbaum, Kaoru Ishikawa, Joseph M. Juran, Genichi Taguchi, and others took the quality movement beyond statistical control to the broader realm of reliability engineering and quality assurance (Garvin, 1988; Gehani, 1993; Hunt, 1992, 1993). During the 1970s, many Western businesses allowed quality-management skills to deteriorate, but, by the mid- to late-1980s, some firms had rediscovered the importance of paying attention to quality. There has been a consequent preoccupation with how to implement TQM, and the academic literature has reflected this interest through its principal concern with process issues. The content of TQM, which is defined here as *the substance of TQM activities that have an impact on firm performance and/or the ability to compete,* has not received the same attention.

There is no consensus on a single definition for TQM (Gehani, 1993). We see TQM as a business-level strategy, and, like any such strategy, its

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components of process and content, when considered individually, are necessary but not sufficient conditions for success. As the cover story in *Business Week* (Greising, 1994: 54–59) clearly illustrated, it is too easy for managers to become overly enamored with the procedures and mechanisms of TQM while forgetting that the point of the activity is to improve firm performance and, as the scientific-equipment maker Varian Associates Inc. found, quality can go up, but profits can go down. Other firms, like Federal Express, which won the Baldrige award in 1990, have been caught in the same trap of focusing too heavily on process at the expense of content (Greising, 1994). However, both Varian and Federal Express have now increased their focus on the "what" of TQM, while still attending to the "how." AT&T has gone further and is now not only requiring improvements to product or service quality but is also insisting that each quality initiative must make a return of at least 10 percent on investment (Greising, 1994). The good news is that some firms have realized the need for a balance between process and content in TQM. The purpose of this research is to help restore the balance in the academic literature and, in so doing, we draw on both current theory and ideas that first emerged 30, 40, and more years ago.

Hofer and Schendel (1978) were explicit in their separation of strategy content from strategy process, and their views have been adopted in this work. They maintained that "the types of strategies that produce the best results differ in different types of environmental circumstances, but that there are broad generic patterns to such strategies" (1978: 203). Miles (1982: 15) employed this same perspective to explain that, in addition to being able to choose strategy content so that the firm can align itself with its environment, "[t]he choice of *internal structures and processes* . . . can serve two purposes related to the alignment problem." (See also Galbraith & Kazanjian, 1978, for an extended discussion of process issues.) Paraphrasing Miles, the process side of strategy allows firms to direct competencies and resources in support of a new strategy, or it permits internal reorganization and adjustment to achieve environmental alignment for an existing strategy. Even though the tendency in the TQM literature has been to focus on implementation and the associated problems of supporting new TQM strategies (e.g., Band, 1991; Banker, Potter, & Schroeder, 1993; Barclay, 1993; Blackburn & Rosen, 1993; Cole, Bacdayan, & White, 1993; Hunt 1992, 1993; Johnson, 1992; Krishnan, Shani, Grant, & Baer, 1993; Reger, Gustafson, DeMarie, & Mullane, 1994; Schmidt & Finnigan, 1992; Sparks & Dorris, 1990; Waldman, 1994), some attention has been paid to firms with strategies already in place (e.g., Ebhrahimpour & Cullen, 1993; Lascelles & Dale, 1989; Mohr-Jackson, 1992; Reitsperger & Daniel, 1991; Turney & Anderson, 1989). With some exceptions (e.g., Dean & Evans, 1994), there is a relative paucity of discussion on TQM content.

This article is divided into three main parts. In the first part, we consider the issue of firm orientation (customer orientation and operations orientation) and explore the content of TQM. The arguments pre-

sented are directed toward what Chandler (1962: 8) defined as an industrial enterprise: "a large private, profit-oriented business firm involved in the handling of goods in some or all of the successive industrial processes from the procurement of raw materials to the sale to the ultimate consumer." Although it is possible that the framework (or parts of it) developed in this work could apply to firms in service industries, not-for-profit organizations, or nonprofit organizations, discussions of such applications are beyond the scope of this article. We focus firmly on business-level activities for manufacturing firms, and all our arguments are based on the assumption that firms employ TQM to improve their competitiveness and/or their profitability. In the second part of the article, we are concerned with the relationship between TQM and improvements in revenues and/or reductions in costs. Research propositions, which are intended to guide future empirical work on TQM, are raised during discussions in this second section and focus research attention not only on TQM content and performance improvements, but also on which combinations of firm orientation and uncertainty in the environment those improvements will or will not be found. From this, it becomes apparent that TQM is not a panacea; not all the payoffs from TQM are quick to appear, and a lack of fit or match between a firm's orientation and its environment may lead to reduced performance. In the third part, we address issues that modify the model built in the previous section. We also consider the implications for research and practice.

Finally, we view "quality" in TQM in a way that is commensurate with current thinking. Quality not only means conformance to specifications, but it also means meeting or exceeding customer expectations (Reeves & Bednar, 1994). Thus, quality has implications not only for the way that products are made but also for the way that they serve the needs and wants of customers.

FIRM ORIENTATION AND TQM CONTENT

The importance of considering firm orientation is an idea that is already accepted within the TQM literature; for example, although they mainly addressed process issues, Shiba, Graham, and Walden (1993) related TQM to the concepts of "company focus" and "customer focus." The idea that firms can be oriented toward their internal operations or toward their customers and markets is firmly embedded in the management literature. Ansoff provided a description of the historical development of business thinking, and he noted for the "production era" (circa 1900–1940) that "the focus of industrial activity was on elaborating and perfecting the mechanism of mass production which progressively decreased the unit costs of products" (1979: 22). He also noted that during this period the concept of marketing was effectively limited to offering a standard product at the lowest cost and that the orientation of most firms was on increasing internal efficiency and productivity. This idea is clearly

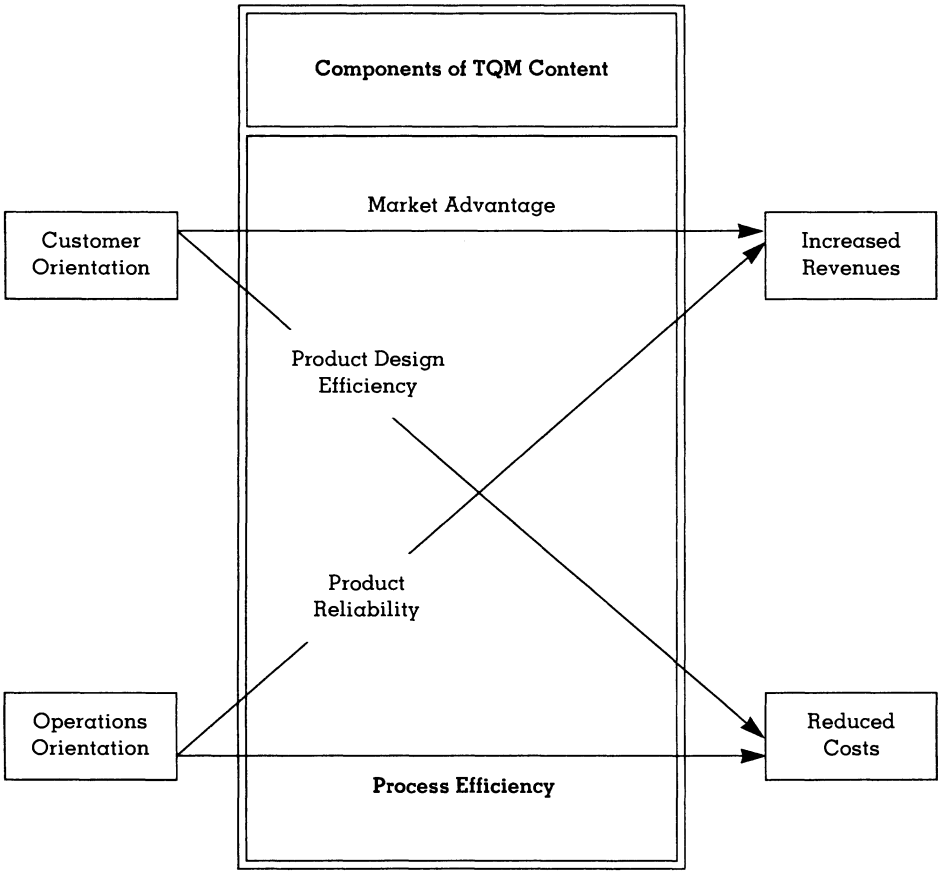
reflected in the work of management theorists of the time such as Frederick Taylor, the Gilbreths, Henri Fayol, and Lyndall Urwick. The production era was followed by the "mass-marketing era," which was characterized by an increasing orientation toward customers and their wants and needs (Ansoff, 1979). Marketing concerns consequently began to play a significant role in strategy formulation, and the emphasis on research and development for the generation of new products also came to full fruition. The thinking and theory from both these eras are still strongly in evidence today. For example, Treacy and Wiersema (1993: 84) discussed value disciplines in business and stated that "companies pursuing operational excellence concentrate on making their operations lean and efficient, while those pursuing a strategy of customer intimacy continually tailor their products and services to fit an increasingly fine definition of the customer." This idea is also evident in Porter's seminal (1980) work on generic strategies: A cost-leadership advantage relies heavily on the ability to improve the operational efficiencies in the firm's value chain, whereas a differentiation strategy focuses on the customer and providing products or services that are distinct from those offered by competitors.

Figure 1 shows the relationship between firm orientation and the content of TQM, and it provides a framework for structuring discussions on the subject. From the figure, it can be seen that firms with a customer orientation should be equipped to successfully pursue a market advantage to increase revenues and product-design efficiencies to reduce costs. Those with an operations orientation should be able to successfully pursue process efficiency improvements to reduce costs and improved product reliability to enhance revenues. As an aside, a customer orientation and an operations orientation should not be confused with external and internal orientations, respectively. A customer orientation helps the firm deal with both external and internal issues (specifically, market advantage and product-design efficiencies), as does an operations orientation (specifically, process efficiencies and customer needs for product reliability).

Customer Orientation

Although customer orientation has traditionally been seen as being equivalent to the marketing concept (Levitt, 1969), more recent research and thinking suggests that it is also much more. Having a customer orientation currently means that the firm is able to create value for customers because it understands their value chain (see Porter, 1985). It also means that the firm is committed to the generation of market intelligence and the organizationwide response to that intelligence (Jaworski & Kohli, 1993; Kohli & Jaworski, 1990; Kohli, Jaworski, & Kumar, 1993). Narver and Slater (1990) were the first to test the relationship between a "market orientation" and firm performance. Their model of market orientation includes concern for customers' needs, concern for competitors' offerings, and interfunctional coordination of activities in the firm; it therefore

FIGURE 1
Firm Orientation, TQM Content, and Performance



equates directly to what others have called customer orientation. Their findings showed that customer orientation has a positive relationship with firm profitability, and a more recent study by Deshpande, Farley, and Webster (1993) provided additional support for that relationship. It is worth noting that their measurement of customer orientation came from customers, and not from managers within the organizations being studied, and similar to work by Kohli and Jaworski (1990) and Kohli, Jaworski, and Kumar (1993), their work highlighted the importance of accurate market intelligence for a customer orientation. These studies thus provide implicit support for Narver and Slater's (1990) customer (market) orientation model. In turn, we are able to relate the components of that model to TQM and the sources of improved firm performance. Specifically, increased revenues arise from establishing a market advantage, which is dependent on being market driven (i.e., responding to customer needs and competitors' offerings), and reduced costs can be achieved from effi-

ciency in product design from value engineering, which requires interfunctional coordination.

Market advantage. A market advantage means that a firm is generating (supernormal) profits by attracting more customers than competitors and retaining these customers longer, and/or the firm is able to charge a premium price for products. These conditions occur when customers' needs are being better satisfied than they can be by rival firms' offerings.

Because quality means both producing products to specification and meeting customers' expectations, the needs of customers becomes a key input to TQM. Deming (1986) and Juran (1992) stressed, among other things, the importance of serving customers by improving product quality. George (1992), Haavind (1992), Hart and Bogan (1992), and others pointed out that the requirements of the Baldrige award demand that firms also consider customers' requirements, expectations, and satisfaction. These arguments are consistent with early explanations of the marketing concept, which included the identification of the relationship between profits and attention to customers' needs (Brech, 1953) and, subsequently, attention to the marketing mix (Houston, 1986; Kotler & Zaltman, 1971). However, even this leaves much unsaid, and the idea of being market driven is more in tune with current business thinking.

Ames and Hlavacek (1989: 28) stated, "Market driven managers recognize that a business is defined by the changing needs and requirements of customer groups and competitive offerings, not by existing products, technologies or management experience." That is, a firm that is market driven uses market intelligence to help anticipate customer needs and to stay ahead of the competition. Day (1990: 357) made a similar point, and, after stressing that customer orientation is an antecedent for being market driven, he argued that "market-driven organizations must meet a dual standard: keep close to the customer, and ahead of the competition." This duality in the theme is aimed at gaining and sustaining a competitive advantage.

Competitive advantage can be decomposed into component parts that either generate improved revenues or reduce costs. From Porter (1985) and from Day and Wensley (1988), we can deduce that market-driven firms can establish a market or positional advantage that produces increased market share (or reduced elasticity of share) and that, in turn, provides improved revenues. Dean and Evans (1994) provided similar arguments about the relationship between TQM and competitive advantage by linking improved quality with higher prices and increased market share. On the question of advantage and costs, the arguments of Porter and of Day and Wensley suggest that attention to operational efficiencies is the preeminent concern, rather than attention to customers' needs or competitors' offerings. However, as the TQM literature points out, cost reduction also can be achieved through product-design efficiencies.

Design efficiency. In TQM, the design of new products or the modification of existing products falls under the broad heading of simultaneous

or concurrent engineering (Schmidt & Finnigan, 1992). These design activities demand attention to the requirements of customers and to interfunctional coordination (recall that customer orientation includes concern for customers' needs, concern for competitors' offerings, and interfunctional coordination of activities). Simultaneous or concurrent engineering includes an array of techniques like the Taguchi design method, design for manufacturability, design for assembly, and quality function deployment (QFD). QFD, which is a widely adopted technique, is the most prominent in the literature (e.g., Dean & Evans, 1994; Griffin & Hauser, 1992). Because QFD is primarily concerned with the relationship between customer needs and new product attributes, it supports attempts to establish a market advantage. However, similar to other techniques, QFD is also concerned with reducing the costs of production. The heritage of all these techniques is clearly visible in the older and comprehensive procedures of value engineering and value analysis (VE/VA[1]), which originally was developed and put into practice by General Electric in 1947. Reuter (1985: 25) explained that

> VE/VA can be defined as "an organized, systematic study of the *function* of a material, component, product, or service, with the objective of yielding value improvement through the ability to accomplish the desired function at the lowest cost without the degradation of quality" . . . [and] the objective of VE/VA is to achieve equivalent or better performance at a lower cost while maintaining all . . . quality requirements.

Thus, every component and part of a product or service is individually examined to see if it provides value to the customer. If it passes the test, then the firm charges the customer an economic (market) price for that component. This concept is commensurate with QFD and product differentiation, and with being able to generate revenues by charging for the additional product features. The problem, as Zurier (1992) pointed out, is that having identified a product feature that adds value for customers, firms appear to have difficulty determining whether they should charge for it and, if so, how much. Consequently, most VE/VA-based approaches to product design are used to improve design efficiencies and reduce costs (Reuter, 1985).

If the component does not provide value, then the following questions must be asked: Can it be eliminated? If not, can it be produced more cheaply and/or made to serve more than one function? Thus, although the main emphasis is to reduce the costs of production by improving or simplifying design, VE/VA is still driven by the need to provide customers with a product that satisfies their requirements. VE/VA also can be used

[1] A form of value analysis has been adopted in reengineering where it is applied to processes, rather than products, and is called PCVA (process-based cost/value analysis; see, for example, Housel, Morris, & Westland, 1993).

to eliminate excess quality from a product (Chase & Aquilano, 1973; Gedye, 1968; Reuter, 1985). Prima facie, this notion appears to be an anathema to TQM, but the underlying rationale is, in fact, consistent. For example, it is pointless to demand that engineering tolerances be .001 inch if .01 inch is perfectly acceptable and less expensive. Secondary and synergistic gains also can result from fewer but more robust and well-designed components (i.e., improved quality of output and better product reliability for customers), and the costs of defective production also can be reduced.

Operations Orientation

Unlike the customer-orientation construct, operations orientation has never been fully defined nor measured, yet it has face validity, and there is a wide acceptance of the concept within the business literature. The notion of an operations orientation is grounded in classical management theory (e.g., scientific management), and it underlies much of our current management theory and models of organization that deal with the internal control of the firm and the governance of its activities. Spencer (1994) examined seven factors (goals, definition of quality, role/nature of the environment, role of management, role of employees, structural rationality, and philosophy toward change) that broadly explain management practice and found substantial overlap between thinking in TQM and the theory embedded in the mechanistic, organic, and cultural models of the organization. Similarly, Dean and Bowen (1994) identified substantial overlap between TQM and management theory. This result should not be surprising because Deming and other advocates of the quality movement have focused heavily on the same issues as many management theorists. As Spencer (1994) pointed out, they also have suggested that managers would do well to increase their focus on improving the efficiency and control of the firm's operations.

Process efficiency. Juran's (1951) *Quality Control Handbook* was probably the main catalyst for moving the field of quality management beyond the control of manufacturing to include all operations in the firm. In it, the idea was established that substantial cost savings were possible through a full array of firm activities. The TQM literature points out that the earlier that defects are detected, the less expensive they are to correct (e.g., Garvin 1988), hence, normative recommendations that statistical controls and conformance to specifications be applied to all stages of production (Crosby, 1979, 1984; Deming, 1982, 1986).

The importance of low costs is well established in the competitive-advantage literature (e.g., Day & Wensley, 1988; Porter, 1985) and, for the operations-oriented firm, a cost-based advantage may be seen as corresponding to the market advantage in the customer-oriented firm. However, a cost-based advantage can be generated from economies of scale, power over suppliers, and more, and, in TQM, the concept of continuous (process) improvement is considered the main tool for improving efficiency. Therefore, we have refrained from balancing market advantage

with cost advantage (see Figure 1). Continuous improvement is sometimes seen as being equivalent to Kaizen—the never-ending attention to detail that reduces the effort and time that it takes to conduct operations (Schmidt & Finnigan, 1992). However, continuous improvement is a broader concept than Kaizen that has more in common with the economic concept of experience-curve effects. Hunt (1993: 46), for example, stated that "continuous improvement depends on both innovative and small incremental changes."[2] He went on to point out that incremental improvements are necessary to build on the performance standards set by innovations in processes that arise from the application of new technologies and research and development efforts. These issues demand some further discussion.

According to microeconomic theory, profit-maximizing firms seek the point of lowest cost and, if all else is equal, they will operate at the minimum point on the quadratic economic-conformance-level cost curve. That is, firms will seek the low point on the U-shaped curve that results from trading off the cost of reworking defective products against the cost of eliminating defects. Juran (1988) and Gilmore (1990) subscribed to this view of the world, but others have maintained that improved product quality reduces the cost of scrap and rework and, thus, may be considered "free" (Crosby, 1979, 1984; Deming, 1982). Fine (1986) attempted to reconcile these separate views of minimum cost by incorporating the idea of learning into the logic; that is, over time, the economic conformance level will move toward zero defects as the costs of identifying quality problems disappear through improvements in processes. However, we should point out that these two sets of thinking are based on different assumptions. The first view implicitly assumes that a firm's management is fully cognizant of the firm's activities and alternative methods of operation, whereas the "quality is free" point of view assumes that managers tend to be unaware of the full amount of rework and its true cost and, therefore, operate at a suboptimal position on the rework-prevention cost curve.[3]

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[2] Hunt (1993: 46) also provided an excerpt from a report by Mansir and Schacht, of the Logistics Management Institute, which stated that continuous improvement "complements and animates the principles of process orientation and customer focus and involvement with the certain recognition that no process, product, or service ever attains perfection and that neither the customer's expectations nor the quality of the competition remains static." Two points of interest emerge here: (a) the idea of customer or operations orientations is readily recognized, and (b) the term *continuous improvement* has been expanded to include aspects that overlap with QFD and being market driven. This latter point reflects how the name has changed over time from "continuous process improvement" to become simply "continuous improvement."

[3] A reviewer pointed out that continuous improvement may not provide equivalent benefits for all firms. If uncertainty is low, it is fair to believe that most firms will be amenable to seeking the benefits of continuous improvement. However, factors like adaptive rationality (Cyert & March, 1963) may produce uneven or lumpy gains in efficiency for some organizations. If there is causal ambiguity in operations (Lippman & Rumelt, 1982), gains in

Fine (1986) argued that attempts to improve quality will lead to a better understanding of the firm's processes that can translate into lower production costs (see Belohlav's, 1993, discussion of Motorola for how improvements in quality and efficiency are linked). Deming (1982) took the idea further and suggested that even if operations are producing quality output without the inefficiencies associated with rework, they still can be examined to find even more efficient ways of achieving the same outcome. Although this notion has an obvious overlap with economic theory on learning, experience effects, and reducing the long-run average cost, it adds something new. It moves beyond the usual assumption that manufacturing capabilities are static, acknowledges that firms may not already be using the best methods, and thus allows for changes in technologies, materials, and more. With continuous improvement, the firm can create new long-run average cost curves, and each curve can be below the previous one (Gilmore, 1990).

Product reliability. At about the same time it was realized that product quality and efficiency could be improved by attention to processes, firms also started addressing the question of product reliability. Garvin (1988) told of the Department of Defense's becoming a prime mover in focusing firms' attention on product reliability (as well as manufacturing processes) because, in 1950, some two thirds of the Navy's electronic equipment was constantly out of action because of reliability problems. Thus, although both process efficiency and improved product reliability are achieved by focusing on operations, their developments arose from different stimuli. Continuous improvement followed from a need for quality and efficiency, but improved product reliability was forced by consumer complaints about the performance of products in use. Reliability is therefore usually defined in terms of the probability that a product will operate in a specified way, for a prescribed number of times, under given conditions (Garvin, 1988; Hunt, 1992; Vonalven, 1964). Gedye (1968: 76) suggested that "failures in the field, and consequent bad reputation of the product may result either from deficiencies in design . . . or poor conformance with a design which may be satisfactory." In the same vein, the idea of integrating product quality and design was the basis for much of Taguchi's work and his idea of "robust quality" (Gehani, 1993) that stresses the refinement of manufacturing processes and their operation at optimum levels to reduce the variations in output that adversely affect a product's quality and reliability.

Juran (1988) summarized the issue of reliability well when he suggested that product performance leads to customer satisfaction, but product deficiencies lead to customer dissatisfaction. There are hidden costs

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efficiency may be indeterminate and depend heavily on the tacit knowledge of employees and their understanding of complexities in operations (Reed & DeFillippi, 1990). These and other elements that affect the process of TQM will moderate its potential for improving performance.

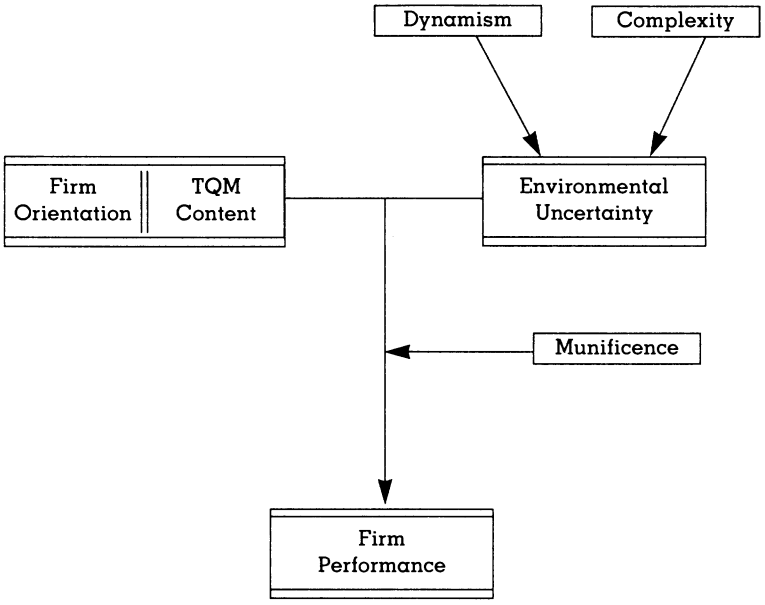
that exist when firms offer products with poor quality and reliability (Belohlav, 1993). Gedye (1968) pointed out that although the cost of replacing unreliable goods under warranty may be easy to calculate, the effect on the firm's image and reputation, and thus the effect on future revenues, is a much more difficult task. Low product quality creates dissatisfied customers who will not only be more open to considering competitors' offerings but also will be likely to discuss their dissatisfactions with other potential customers. In short, improving product reliability can improve firm revenues.

TQM, ENVIRONMENTAL UNCERTAINTY, AND FIRM PERFORMANCE

In the organization theory literature, researchers have long held that how firms interact with their environment is important for performance (e.g., Perrow, 1967; Thompson, 1967). Lawrence and Lorsch (1967) explored integration and differentiation (within and between firms) in the stable environment of the canning industry and the more dynamic environments of food processing and plastics. They found that strategies were contingent upon the environment and that firms in the volatile food and plastics industries dealt with uncertainty by innovating to satisfy customer needs and wants, whereas those in the low-uncertainty canning industry focused on product consistency and production efficiency. Sitkin, Sutcliffe, and Schroeder (1994) drew on contingency theory and argued that TQM should include two goals—control and learning. Through the control goal, firms focus on improving repetitive activities, whereas, for learning, the focus is on new products and process innovations. With control there is an emphasis on "doing it right the first time" and on improving existing strengths, but, with learning, new strengths are being developed and errors are likely to occur. Errors or small failures are not necessarily a problem because they can lead to learning and adaptability (Sitkin, 1992), and, with uncertainty, such abilities are to be valued. Where uncertainty is low, concentration on control in TQM provides the most appropriate fit, and where uncertainty is high, a concentration on learning provides the best fit. The idea that the success of TQM is a function of the "interrelationship among internal organizational states and processes and external environmental demands" (Lawrence & Lorsch, 1967: 134) that underpins Sitkin and colleagues' arguments also can be applied to the broader classifications of customer and operations orientations that are used here in the examination of TQM content and its implications for firm performance. Where Sitkin, Sutcliffe, and Schroeder use contingency theory to consider TQM-process issues, we use it to consider content (see Figure 2).

Despite some differences in the conceptual lens through which various contingency theorists view organizations, there is universal agreement on the importance of environmental uncertainty. For the purposes of our study, we consider environmental uncertainty in terms of dimensions proposed by Dess and Beard (1984)—dynamism, complexity, and

FIGURE 2
Orientation, TQM, Uncertainty, and Performance



munificence. *Dynamism* refers to the unpredictability of the (in)stability in the environment; *complexity* represents a continuum ranging between homogeneity and heterogeneity; and *munificence* depicts the environment's ability to sustain growth. Our interest is primarily with the first two dimensions, which are consistent with the classic contingency-theory literature (Burns & Stalker, 1961; Thompson, 1967) and which fit well with Lawrence and Lorsch's (1967) contingency criteria of rates of technological change (dynamism) and demands emanating from different sectors of the environment (complexity). In our work, munificence is treated as a boundary condition and, thus, is held constant.

The use of contingency theory necessitates some discussion on the concept of fit, which can be defined in several ways. We have adopted the "fit as matching" definition, where "fit is a theoretically defined match between two related variables . . . [and] . . . is specified without reference to a criterion variable, although, subsequently, its effect on a set of criterion variables could be examined" (Venkatraman, 1989: 430). This type of fit occurs, for example, when a firm diversifies and adopts a divisional structure to match its strategy. With this definition, we are taking the position that it is fit (match) that is important in determining performance, and not the independent effects of environmental uncertainty, and firm orientation and TQM.

Achieving performance benefits from a strategy depends on both its content and the process of implementation and control. So, in the follow-

ing discussion we have assumed the ceteris paribus condition for all process issues in TQM to allow us to focus on the content-performance relationship. With regard to performance, we also address the issue of time lags. Some critics of TQM highlight the lack of immediate benefits (e.g., Myers & Ashkenas, 1993; Schaffer & Thomson, 1992), but, as the following arguments illustrate, there are valid reasons why some of the gains from TQM are far from instantaneous. Uncertainty and firm orientation both exist on continua and, to permit easier translation into testable hypotheses, arguments are made and propositions are stated in polemic terms. Both continua are unidimensional; uncertainty ranges between high and low, and orientation ranges between customer and operations.

Customer Orientation

Market advantage. As Lawrence and Lorsch (1967) found, attention to customers is paramount when environmental uncertainty is high. Being market driven means anticipating and responding to customers' needs and preempting competitors to produce an increase in market share and/or reduce the elasticity of demand (for a discussion on the relationship of market share and differentiation with firm performance see Prescott, Kohli, & Venkatraman [1986] and White, [1986]).[4] Because this proactivity means moving with some speed, the firm that adopts TQM to create a market advantage is able to generate increases in revenues sooner rather than later. Being market driven also means using marketing techniques such as segmentation and adjustment of the marketing mix to help sustain any advantage. We would expect consumer responses to such changes to happen quickly and, therefore, again, resultant increases in revenue should appear sooner rather than later.

Regarding low uncertainty, there is, by definition, little change in product technology in customers' needs, and demand is predictable. The supply side of the equation is also stable, and conditions that approximate equilibrium exist with little change likely in the firms that are competing in the marketplace. Therefore, where products can be differentiated, adept competitors will have had time to differentiate their product, to adjust their marketing strategies, to optimize segmentation and to arrive at the best marketing mix, or they will have had time to imitate the market leaders. Because customer needs are being met, changes in the firm's marketing strategies are thus unlikely to create any additional advantage. In fact, changes in target markets, in advertising, in distribution patterns, in product features, and in packaging could have adverse effects and create consumer dissonance, leading to lost sales and

[4] Where the relationship between differentiation and performance is clear (see White's, 1986, analysis), the relationship between market share and performance is more widely disputed (see Prescott, Kohli, & Venkatraman's, 1986, summary and analysis, which shows that the market-share-performance relationship is contingent upon several factors).

lower repeat purchases. At best, such changes would have no effect on consumers' purchases and would simply result in additional marketing costs for the firm. These arguments lead to the following propositions:

> *Proposition 1a: Firms with a customer orientation that use TQM to generate a market advantage will realize benefits of growth in revenues when uncertainty is high, whereas similar firms that use this approach in environments with low uncertainty will incur penalties of revenue losses and/or increased marketing costs.*

> *Proposition 1b: The time lag after implementation of TQM for the appearance of either associated benefits or penalties will approach zero.*

Design efficiency. The benefits that can be gained from more efficient product designs have been found to be substantial. For example, Mobley and Schwitter (1967) pointed out that firms that used VE to simplify product design generated returns of 800–1000%, and Reuter (1985) provided case examples of firms using VE/VA, in which the returns were even higher and the payback periods were very short. Thus, when environmental uncertainty is high, and frequent product changes are necessary to satisfy the changing needs of customers, VE/VA becomes a valuable vehicle for cost control and, like the payoff from a market advantage, cost savings from adopting a simpler product design should start accumulating soon after it is implemented.

When uncertainty is low, and there is little or no demand for product change, we would expect that all firms would have reverse engineered all competing products, and that the most efficient design would have emerged as dominant. VE/VA techniques therefore may not produce significant cost savings. Considering whether product features add value for the customer and, if not, considering whether they can be eliminated, or whether a simpler construction or different materials can be used demands communication and coordination among marketing, manufacturing, design, and sales, and it carries administrative costs. Thus, at the extreme, there will be no cost savings, but additional costs for the administration of interfunctional coordination will be incurred. Additionally, any subsequent redesign, retooling, or finding new suppliers carries further costs. This leads to the following propositions:

> *Proposition 2a: Firms with a customer orientation that use TQM to improve product-design efficiency will realize benefits of reductions in costs when uncertainty is high, whereas similar firms that use this approach in environments with low uncertainty will incur penalties of additional administration costs and expenditures.*

Proposition 2b: The time lag after the implementation of TQM for the appearance of either associated benefits or penalties will approach zero.

Operations Orientation

Process efficiency. Lawrence and Lorsch's (1967) work suggested that firms should focus on controlling production costs when environmental uncertainty is low. Alchian (1963) and Preston and Keachie (1964) were in the vanguard of scholars who examined the effects of learning on long-run average costs of production and, similar to most researchers who have replicated this type of study (e.g., Lieberman, 1987), they concluded that it is possible to constantly reduce costs by using employee experience to successively seek better ways of performing the same task. As pointed out previously, TQM and continuous improvement go beyond the assumptions on the static nature of manufacturing capabilities that underlie these studies and, by incorporating the idea of major process innovations, firms can move to new, lower long-run average cost curves. However, new processes, new ways of organizing the firm, and using new technologies all have to be learned, and moving to a new cost curve will increase costs in the short term. This produces a saw-tooth effect on the cost curve, and, as time passes and employee experience accumulates, the firm moves down its new cost curve and eventually reaches points below the cost level that it had before it adopted the new, improved method of operation. Having achieved this, the firm then seeks new and even more improved processes and means of operation—hence, the idea of continuous process improvement.

Where there are high levels of uncertainty, firms' attempts to retain strategic flexibility may be considered more appropriate than increasing the specialization of existing operations. An increased commitment to one particular way of doing things will logically increase the costs of change when the external environment demands process and organizational adaptation. Thus, attempts to make existing operations more efficient through continuous improvement may generate more costs than savings. This is particularly true where continuous improvement includes major process innovations or organizational changes (remembering that a major change involves increases in cost as the firm moves onto a new experience curve). The Kaizen approach, with its incremental change, may be less risky, but with rapid change its returns will be severely restricted.

Proposition 3a: Firms with an operations orientation that use TQM to generate process efficiencies will realize benefits of reductions in costs when uncertainty is low, whereas similar firms that use this approach in environments with high uncertainty will incur penalties of increased production costs.

Proposition 3b: The time lag after the implementation of TQM for the appearance of either associated benefits or penalties will not only be significantly greater than zero, but also will be preceded by cost increases that are created by learning a new process of operation.

Product reliability. The relationship between product reliability and performance has remained untested in the literature. Therefore, we must rely on conventional wisdom that suggests that the relationship exists and that there is a net positive benefit to revenues from improved product reliability. Products must be used by customers over time to demonstrate that such reliability exists, and it therefore takes time to build a reputation for reliability. Only at this point will others who are sensitive to long-term product reliability become customers, too. There is an interesting point that arises here in terms of repeat purchases—increased reliability means that customers will not make repurchases as soon or as often. Although the lost revenue can be made up through being able to charge a higher price for better reliability (differentiation), that cannot be done until the reputation for reliability has been established. Like the payoff from improved process efficiency, it seems fair to believe that the payoff from enhanced product reliability will take a substantial amount of time to materialize.

For product reliability we may assume that products conform to specifications (as discussed previously) and that the main issue of interest in TQM is improving or enhancing product reliability. If uncertainty reflects changing customer needs and changing product technologies, it is likely that customers will renew their product purchases with some regularity. Long-term or enhanced reliability in products may not be an issue of concern as customers update or exchange products before they have chance to wear them out (e.g., as with high-fashion clothing). Either including better quality materials in the construction of products or producing them to industrial-design-type standards to increase longevity will therefore be, all else being equal, unlikely to impress customers sufficiently to allow the firm to charge higher prices to cover any consequent increased costs. In other words, the conditions of demand that reflect uncertainty make it difficult to successfully differentiate products on the basis of long-term reliability. This leads to the following propositions:

Proposition 4a: Firms with an operations orientation that use TQM to improve product reliability will realize benefits of growth in revenues when uncertainty is low, whereas similar firms that use this approach in environments with high uncertainty will incur penalties of increased production costs.

Proposition 4b: The time lag after the implementation of TQM for the appearance of associated benefits will be

significantly greater than zero, but the time lag for penalties will approach zero.

Summary

Miles and Snow (1994) pointed out that firms that have a match with their environment can improve their performance, but those that have a mismatch, or respond too slowly to change, court failure and poor performance. The arguments presented here on firm orientation, TQM content, and environmental uncertainty reflect Miles and Snow's sentiments. It was reported in *The Economist* (1992) that three fourths of U.S. and British firms claim to have some form of TQM program in place, but, even though there is great interest in TQM, problems and dissention are beginning to appear. Harari (1993) listed 10 reasons why TQM does not work, Papa (1993) suggested that after 18 months or so, TQM practices can revert to the old ways, and Myers and Ashkenas (1993) discussed ways to stop TQM from becoming another expensive and unproductive fad. This dissatisfaction with TQM is, more often than not, linked with the criticism that the expected results have not materialized, or that performance has actually decreased after its implementation. As we have argued, some benefits will not appear quickly; expectations to the contrary will lead to disappointment.

ISSUES AND IMPLICATIONS

To ease the theory-building process, we have thus far focused on the ends on the uncertainty and orientation continua. We also need to spend some time exploring the middle ground where firms have an orientation that is split between customers and operations, and where uncertainty can cover the full range of possibilities, including medium levels. This, and the condition of prior performance, which can moderate the success of TQM, along with implications for research and practice, are discussed next.

Mixed Orientation

When a firm's orientation falls between customer and operations (i.e., there is a dual focus), but where the environment contains either high or low uncertainty, performance gains from TQM will be elusive. When uncertainty is high, revenue gains from a market advantage and reduced costs from VE/VA will be limited or erased by increased costs associated with attempts to improve process efficiencies and enhance product reliability. Conversely, with low uncertainty, the reduced costs from improved process efficiency and increased revenues from product reliability will be reduced or negated by the costs of attempting to establish a market advantage or using VE/VA. These same conclusions can be reached when uncertainty is held constant at a midlevel, and orientation

is allowed to vary. This logic is in line with the thinking of Miles and Snow (1994), who suggested that whereas a bad match will probably lead to failure and losses, an imperfect match is unlikely to produce a significant effect on performance. Thus, the performance benefits that are to be gained from TQM where there is only a partial match between environmental uncertainty and a firm's orientation and TQM content will likely be less than in situations where a complete match is found, but greater than in situations with a full mismatch.

Bearing in mind that the ratio of emphasis on customers to operations is infinitely variable, some approximately equal blend of attention to the two should allow firms to match environments where there are medium amounts of uncertainty. Although the determination of what constitutes medium levels of uncertainty remains an empirical question (see, for example, Lawrence & Lorsch, 1967), this situation should occur when dynamism is high and complexity is low (or vice versa). Under these conditions, we would expect to find payoffs from establishing a market advantage, from more efficient product designs, from process efficiencies, and from improved product reliability. Even though the revenue-generating capability of a market advantage and product-reliability improvements and the cost-saving capacity of continuous process improvement and VE/VA would be damped by the medium amount of uncertainty, firms should be able to include all four aspects of TQM content in a quality program rather than just the two that are appropriate when environments have either very high or very low uncertainty. Performance benefits will appear quickly from any market advantage and product-design efficiencies, but they will, of course, take longer from process efficiencies and product reliability. The medium amounts of uncertainty in the environment means that gains from continuous improvement may be riskier than gains for firms in environments with low uncertainty; they also may be curtailed as change occurs. However, such curtailing of returns may not be significant if diminishing returns to experience-curve effects have set in. Thus, for firms with a dual customer and operations orientation, operating in environments in which there are medium amounts of uncertainty (i.e., a match exists), performance gains should not be significantly different from other firms using TQM where a match with their environment exists.

The Contingency of Prior Performance

Practice has shown that a payoff from TQM depends on the way it is implemented (Greising, 1994; Port, Carey, Kelly, & Forest, 1992) and, interestingly, on firms' abilities and performance prior to implementation (Ernst & Young and the American Quality Foundation, 1992). For example, the technique of benchmarking in TQM works well in firms that have a culture that is geared to improvements in quality, but it works best in firms that also have good performance. It may have no effect on midlevel firms, and it can have a deleterious effect on firms that are plagued by

poor performance. It also has been pointed out that the firms that benefit most from TQM are those that implement it during a period of prosperity and are consequently able to stick with the program for several years (*The Economist,* 1992). These observations can be synthesized with the arguments in this article: TQM programs work well when there is a match between environmental uncertainty and a firm's orientation, but TQM can create poor performance when there is a mismatch and, if a mismatch is already leading to poor performance, we would expect the adoption of TQM to aggravate the problem.

Poor prior performance does not necessarily mean that an uncertainty orientation mismatch exists, and it does not necessarily mean that TQM will fail. It has been reported how firms that have been successful with TQM were motivated by the need to overcome poor performance (see, for example, Haavind's, 1992, numerous case discussions). This whole performance issue raises an additional interesting research question about how the relationship among TQM content, its process, and the match with the environment are moderated by previous experience. Specifically, do firms learn from their previous failures (Sitkin, 1992), and thus become more open to the adoption of TQM practices, or if they have tried TQM, do some initial small successes spur the firm on to broader adoption and greater successes (Weick, 1984)? It is well documented that (a) Motorola adopted TQM because of its prior failures in producing high-quality products (e.g., Haavind, 1992; Hart & Bogan, 1992) and (b) Ciba-Geigy adopted TQM companywide after it was seen to be successful in one plant (Levine, 1991).

Implications for Research

Because firms like Motorola and Xerox have had so much success improving their competitive position (Hunt, 1992), it is likely that TQM is here to stay (Schmidt & Finnigan, 1992). Industry experts have pointed out that TQM has been widely adopted in the aerospace industry as a means of helping cope with the effects of the latest recession (Smith, 1991), and this strategy has been sought out by firms that are threatened by military budget cuts (Bond, 1991). Firms have used TQM to respond to competitive threats, and, in the face of such, to improve customer service and (re)gain market share (Szwergold, 1992). It has even been suggested that TQM is expected to improve the productivity of U.S. industry and help ensure that it survives (Scott, 1989). Even if this bold suggestion is only half true, we must be able to research and intimately understand TQM. This article has provided a framework that will help in that investigation and, in testing the model presented here, the following 10 factors need to be addressed.

1. Testing the model presented here will, of course, require operationalization of the constructs. Table 1 provides a summary of research tools to help facilitate that process.

2. The operations-orientation components of TQM content (process efficiency and product reliability) must be tested considering time lags.

TABLE 1
Construct Operationalization

Construct	Direct Measure	Proxy Measure
Uncertainty	Rate of technological change in products and processes, and number of environmental sectors making demands on the industry (Lawrence & Lorsch, 1967); instability (dynamism) measured in terms of sales growth and volatility, and complexity measured in terms of industry concentration (Keats & Hitt, 1988)	Perceived environmental uncertainty (Bourgeois 1985; Duncan, 1972; Ireland, Hitt, Bettis, & de Porras, 1987; Koberg, 1987; Miles & Snow, 1978; Milliken, 1987)
Firm Orientation	Multi-item scales for customer orientation (Deshpande, Farley, & Webster, 1993; Jaworski & Kohli, 1993; Kohli, Jaworski, & Kumar, 1993; Narver & Slater, 1990; Saxe & Weitz, 1982); similar approaches can be used for operations orientation	Content analysis in president's letter for customer orientation (Judd & Tims, 1991); a similar approach can be used for operations orientation
Market Advantage	Competencies, positional advantage, and key success factors (Day & Wensley, 1988)	(Context specific) market share (Prescott, Kohli, & Venkatraman, 1986)
Product Design Efficiency	Savings-cost ratio (Reuter, 1985; Mobley & Schwitter, 1967), and analysis of management functions (Mobley & Schwitter, 1967)	Interfunctional coordination (Griffin & Hauser, 1992); also R&D intensity is appropriate
Process Efficiency	Accounting measures for continuous improvement (Turney & Anderson, 1989); also number of product transformations, direct labor hours, scrap rates, or defects per thousand are appropriate	Activity-based measures (see Olian & Rynes, 1991); cost of goods sold as a percent of sales is appropriate
Product Reliability	Number of product returns, product recalls, customer complaints, or warranty-work information are appropriate; also see Taguchi and Clausing (1990)	Quality-assurance activities (Gilmore, 1990; Juran, 1992); product-testing data are also appropriate
Financial	Cash flow, sales growth, operating income, market share, return on equity (Kaplan & Norton, 1992); cost of goods sold is also appropriate	Subjective performance measures (Dess & Robinson, 1984)

Corning Inc., which has persevered with TQM since 1983, has found that this strategy eventually pays off—operating profits increased 111% in the five years up to 1991 (Hammonds & DeGeorge, 1991). What all of this means is doing longitudinal research. Also, Jensen (1993) pointed out that we are experiencing a second industrial revolution because, among other things, firms are improving their efficiency and, thus, creating spare ca-

pacity in their industries by adopting organizational innovations like TQM. Therefore, in studies addressing efficiency and performance gains over time, researchers should be aware that success with TQM can result in a changed environment with associated changes in uncertainty.

3. Most empirical work that considers firm performance and time addresses the latter in a way that is commensurate with the publication of financial information; that is, the annual reports and accounts for publicly quoted companies generally dictate the use of yearly data. We therefore would expect to find the effects from market advantage and product-design efficiency being evident in the first data point after a TQM strategy was in place (i.e., the phrase "time lag approaches zero" may be interpreted as zero to one for annual data). For the propositions dealing with process efficiency and product reliability, where it is suggested that time lags will be significantly greater than zero, we believe that it is unlikely that the associated effects from TQM will be evident in a period of less than one year. Anecdotal evidence suggests that some time lags can be substantial (see the Implications for Practice section that follows).

4. There may be a contingency of the starting position of the firm (i.e., its previous performance) that affects the success of TQM, and this could cloud the true nature of performance outcomes. Prior performance must be taken into account in analysis.

5. There is the problem of identifying firms that are fully committed to the use of TQM, compared to those that simply pay it lip service, because having a TQM program is the fashionable thing to do (Greising, 1994; Tetzeli, 1992). Inclusion of the latter group in a sample will, of course, obscure the true nature of any results.

6. Industry may have an effect. This does not mean that the whole model or parts of it cannot be tested in a cross-sectional analysis; however, it does mean that a substantially larger sample will be required to maintain statistical power.

7. Problems will likely arise from process issues (which have been set aside here so that the focus could remain firmly fixed on TQM content). The very nature of TQM means that it is a complex, firmwide activity, and full implementation is not something that can be done either quickly or easily (Hunt, 1992). It is also likely that any sample will include firms at different stages in the implementation process, and it would therefore be prudent to include adjustments for the age of TQM programs in any empirical analysis.

8. If environmental uncertainty is measured using managers' perceptions of the environment, researchers must remember that these may not be accurate portrayals of reality. Managers' decisions about TQM programs may color or shape their interpretations of environmental uncertainty, which, in turn, may lead them to make inappropriate adjustments in the continuing implementation of TQM programs. This caveat highlights the importance of the allocation of sufficient resources for environmental scanning.

9. We have held munificence in the environment constant, but its effect on performance cannot be ignored. Resource scarcity will make the necessity of a good match all the more important for generating benefits from TQM, whereas an abundance of resources will reduce the penalties associated with a mismatch.

10. It is likely that differing emphases in implementation will have a bearing on the success of TQM and its performance outcomes. A solution to this problem could be, for example, to use some or all of the Baldrige criteria (leadership, information and analysis, strategic quality planning, human resources development and management, management of process quality, quality and operational results, and customer focus and satisfaction [see Hart & Bogan, 1992; Schmidt & Finnegan, 1992]) as a basis for adjustment for differing emphases. This problem of the interrelationship between content and process and their joint effects on firm performance has, in large part, been ignored within empirical research. Given the importance of both content and process in TQM, and thus to the benefits that it can generate for the firm, researchers are faced with a perfect opportunity to correct this shortcoming.

Implications for Practice

If TQM explains a meaningful amount of variance in performance at the business level, then there are three major points that managers should consider. First, maintaining a focus on the content of TQM is as important as becoming immersed in its process. Second, the match between uncertainty in the environment and firm orientation and TQM must be addressed. Third, some aspects of TQM will require patience and persistence for the payoff to be realized.

It is clear that, similar to other management techniques, TQM is not a quick fix or a "golden egg" solution. TQM is a business-level strategy with components of process and content that both demand attention. As some Baldrige applicants and winners have found out, a slavish adherence to TQM processes, without sufficient attention to content, can be not only a frustrating exercise, but it also can be expensive. For example, the Wallace Company, which was a Baldrige winner in 1990, was forced into Chapter 11. Management of the quality process became an end in itself, and managers spent too much time proselytizing such activities to other companies (Port, Carey, Kelly, & Forest, 1992).

The ideas presented here are underpinned by a considerable empirical literature that suggests that successful firms are those that have achieved a match with their external environment, and, as we have argued, such a match is a necessary condition for the success of TQM. Therefore, managers must understand environmental uncertainty and its attributes of dynamism and complexity (and munificence). Thus, there is also a need for environmental scanning—the continuous, systematic monitoring of changing external conditions—and the subsequent adaptation of the firm's orientation in response to any changing conditions,

assuming that it is easier to change orientation than it is to change the environment. Even so, changing orientation is no small task in that it requires a permanent change to the organization culture in addition to employees learning new skills. Having achieved a match between uncertainty and orientation, there is then the need to ensure that the content of a TQM strategy is appropriate. For TQM programs already in place, this may mean some adjustment to the content. For example, if the uncertainty in a firm's environment increases, and the orientation is adjusted more toward customers and less toward operations, there is no point having content that concentrates primarily on, say, improved process efficiency. Instead, the content should emphasize market advantage or product-design efficiency. TQM programs that do not focus on the right content issues will be unlikely to provide returns on investment and may, in fact, create losses. This was almost the case at United Parcel Service Inc., until it was realized that their delivery drivers were an asset rather than a cost. UPS changed its TQM-content focus to allow drivers more time to interact with customers, to have the chance to generate more sales revenues, rather than simply seeking maximum efficiency in delivery by minimizing time spent with customers (Greising, 1994).

There is a tendency, especially in Western firms, to expect immediate or short-term returns to any new strategy. Commitment, in the long term, is invariably a featured quoin of prescriptions for implementing TQM. Although some outcomes of TQM (market advantage and product design efficiency) will provide returns relatively quickly after implementation, process-efficiency gains from continuous improvement and enhanced revenues from improved product reliability will be slow in materializing. Without realizing this problem, managers may become frustrated at the lack of measurable results (see, for example, Hammonds & DeGeorge's, 1991, interview with the CEO of Polaroid) and programs may be dropped before they have had chance to provide the expected return on the investment. As was reported in *The Economist* (1992), the vast majority of Western firms have had less than a decade of experience with TQM, and many implemented programs for only 2 years before abandoning them, which contrasts sharply with Japanese firms such as Toyota, Nissan, Honda, and Nippondenso, in which quality programs have been used for more than 30 years.

CONCLUSION

Given that the "PIMS literature" provides support for the relationship between product quality and firm performance (see, e.g., Buzzel & Weirsema, 1981; Varadarajan & Dillon, 1981), it seems reasonable to believe that a relationship should exist between the broader construct of TQM and performance. In this article, we have considered that relationship in terms of the content of TQM. Our motivation for looking at content was driven by the fact that the majority of TQM literature focuses on

process issues. As Dean and Bowen (1994) pointed out, TQM is heavy on implementation but light on content, and this is the reverse of the normal situation in management theory. Our framework draws on contingency theory and the idea that firms can be oriented toward their customers, their operations, or both. From this base we identified market-driven strategies and value engineering as being consistent with a customer orientation, and continuous improvement and enhancing product reliability as being consistent with an operations orientation. For conditions of a match between environmental uncertainty and firm orientation, we argued that a market advantage and product reliability can generate revenue growth, and process efficiency and product design efficiency can reduce the firm's costs. A mismatch reduces revenues and/or increases costs. We also considered the relationship between these sources of improved performance and the amount of time it takes to realize the benefits; although those emerging from a customer orientation will produce performance gains relatively quickly, those derived from an operations orientation will have strongly lagged benefits.

Deming (1982, 1986) pointed out that quality management techniques can work as well in service organizations as they do in manufacturing firms. Even though this article has focused on products and manufacturing, there is no reason to believe that the content framework cannot be reworked and adapted to apply to service industries. Similar to manufacturing firms, service organizations (e.g., banks and airlines) can have a customer or an operations orientation, as can nonprofit and not-for-profit organizations. In exploring and extending the arguments made in this work, other interesting questions can be raised. For example, do service organizations tend more toward a customer orientation, because of their high contact with customers, than do manufacturing firms? Do firms that operate in high-value-added industries subscribe to TQM primarily through seeking process-efficiency gains regardless of environmental uncertainty? Does using continuous improvement for process-efficiency improvements lead to sustainable competitive advantage (because of continual improvement in competencies), and is investment in continuous improvement associated with increases in vertical integration?[5] Do other components of TQM, such as seeking market advantage, provide sustainability of advantage, and is this linked with increased asset specificity? Many more interesting research questions will undoubtedly emerge as TQM content is dissected, explored, and tested.

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