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Innovation and Attention to Detail in the Quality Improvement Paradigm

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This study asserted that quality improvement (QI) requires the coexistence of two cultural values of innovation and attention to detail and proposed that their coexistence depends on the implementation of multiple QI practices. A longitudinal QI intervention, with five phases, consisting of multiple QI practices—ISO 9000, QI teams, quality goals, and coaching and communication by top management—was implemented.

Participants were 425 employees working in 18 departments of four manufacturing plants. The QI practices were implemented in a different order in each one of the plants. Measures were assessed five times, at the end of each implementation phase. We used hierarchical linear models (HLM) to account for the nested structure of departments within the plants and the five repeated measures.

Findings demonstrated that the above-mentioned QI practices had differential effects on innovation and attention to detail: ISO 9000 positively affected attention to detail but negatively affected innovation. Both QI teams and quality goals positively affected innovation. Thus, the multiple QI initiative enabled the coexistence of the two aforementioned cultural values. Both cultural values had a positive impact on performance quality and productivity and partially mediated the effects of ISO 9000 on productivity.

Key words: quality improvement initiative; organizational culture; innovation; attention to detail; ISO 9000; teams; goals
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Introduction

In today's fiercely competitive marketplace, companies that want to survive and profit must produce and sustain high-quality products and services. Consequently, numerous companies have implemented quality improvement (QI) initiatives consisting of management practices intended to provide customers with better quality products and services than those competitors offer (Dean and Bowen 1994). However, the popularity of QI initiatives has become the target of increased inquiry, questioning the degree to which QI initiatives in fact improve an organization's performance (Hendricks and Singhal 2001, Staw and Epstein 2000). The limited success of these initiatives has been attributed to superficial implementation (Anderson et al. 1994); lack of emphasis on the organizational-cultural values—essential for quality improvement (Detert et al. 2000); responses to external pressures rather than to the real needs of the organization (Westphal et al. 1997); lack of true leadership with a vision toward quality improvement, rhetoric prevailing over substance (Zbaracki 1998); and too much bureaucracy involved in the quality initiatives (Hackman and Wageman 1995). However, to date there has been no integrative model for identifying the factors that differentiate between successful and unsuccessful implementations of QI initiatives (Dean and Bowen 1994, Hackman and Wageman 1995).

Originally, QI initiatives required high standardization and low variability (Garvin 1988) and had to be supported by an organizational culture (values) advocating attention to detail, precision, accuracy (O'Reilly et al. 1991), and compliance with rules and procedures. However, successful businesses have developed more extensive views of quality, ones that reflect not only zero defects but that also search for innovative products and services. "Disney Magic," for example, is not merely about defect-free rides; it is also about meeting customers' desires for new experiences (Prahalad and Krishnan 1999). Therefore, maintaining the existing rules is no longer enough, and today's QI initiatives should aim to create an organizational culture that emphasizes innovation (Baldrige 2001, Weick 2000).

The present study aims to investigate whether attention to detail and innovation can coexist, how QI initiatives shape the cultural values of attention to detail and innovation, and how QI initiatives and their subsequent cultural values affect performance quality and productivity.

Attention to Detail and Innovation—Two Values of Organizational Culture That Foster QI

Organizational Culture

Organizational culture consistently recurs as a key variable in understanding how employees relate to QI initiatives and in predicting the success or failure of these initiatives. "The one common denominator that led to failure in all our previous quality efforts was that we did not change the culture of the environment in which all these tools and processes were being used" (Sam Malone, Worldwide Marketing Manager at Xerox Quality Solutions, in Detert et al. 2000, p. 850).

Organizational culture refers to a system of shared meaning held by members of the organization (Erez and Earley 1993). According to Schein (1996), culture is a multilevel construct, consisting of an external level of visible and audible behavior patterns; a midlevel representing values that are shared beliefs about what is right and wrong, good or bad; and a deep level of basic assumptions, which are the invisible, taken-for-granted beliefs, perceptions, thoughts, and feelings. The last—basic assumptions—manifest themselves in shared values and norms.

Researchers and practitioners have identified certain types of organizational culture that are strongly associated with successful organizational performance (Barney 1986, Denison and Mishra 1995). In the context of QI, three major cultural values were emphasized: customer orientation, continuous improvement, and teamwork (Baldrige 2001, Dean and Bowen 1994, Weick 2000). Although both the values of innovation and attention to detail are embedded in the underlying philosophy of QI, in practice QI initiatives mainly promote attention to detail and adherence to standards and procedures.

Tension Between Attention to Detail and Innovation

O'Reilly et al. (1991) proposed that attention to detail defined in terms of precision and accuracy is one of the organizational values that comprise the organizational culture. In the context of QI, inaccuracy and lack of precision result in uncontrolled variance in processes and outcomes—the primary cause of poor quality. The need to reduce variability has led to the development of the international ISO 9000 standards, which mandate routines and procedures. Today more than 90% of Fortune 500 companies have implemented quality improvement initiatives in the form of statistical process control, six sigma, and ISO 9000 practices (*Industry Week* 1998). A primary concern of these initiatives is standardization and control (Prahalad and Krishnan 1999), which enhance a culture of attention to detail and conformity.

However, in addition to attention to detail, QI initiatives require innovation as part of the improvement of products, services, and processes and the creation of novel values for the organization's stakeholders (Baldrige 2001). Innovation reflects the pursuit of new and prospective knowledge (Levinthal and March 1993). Emphasis on innovation promotes a culture that encourages responsiveness to new opportunities, breaking existing paradigms, autonomy, risk taking, and tolerance for mistakes. Emphasis on attention to detail, on the other hand, promotes a culture of conformity to rules and procedures, precision, and accuracy.

The literature is inconsistent and presents a variety of perspectives regarding the tension between these two cultural values. One approach identifies a *trade-off* between innovation and attention to detail. This approach stipulates that when attention to detail and adherence to rules increase, innovation decreases (Benner and Tushman 2002, Sitkin et al. 1994).

A second approach suggests that the cultural values of innovation and attention to detail can coexist (Adler et al. 1999, Argote 1999, Brown and Eisenhardt 1998, Levinthal and March 1993, Miron et al. 2004). This approach emphasizes the need to balance these two values. Brown and Eisenhardt (1998) proposed balancing the structure that is vital for meeting budgets and schedules with a flexibility that ensures proper conditions for innovation. Argote (1999, pp. 194–197) has recognized the existing tension between heterogeneity and standardization but points out that some organizations manage to balance both. Quality management philosophy proposes that continuous quality improvement requires attention to detail and conformity to rules on the one hand, and creativity and innovation on the other hand. Thus, the coexistence of attention to detail and innovation constitutes the essence of QI initiatives.

Effects of QI Practices on Attention to Detail and Innovation

New practices implement a new work structure and a new focus, and they have significant consequences for cultural change (Hickson et al. 1969, Miller and Droge 1986). We chose to focus on four types of QI practices that commonly appear in QI interventions: ISO 9000, QI teams, quality goals, and coaching and communication by top management (Anderson et al. 1994, Brunsson et al. 2000, Dean and Bowen 1994). The implementation of these four QI practices introduces changes in focus and work structures that shape the cultural values of attention to detail and innovation.

ISO 9000 Quality Assurance Standard. A major requirement of the ISO 9000 is that organizations develop and implement a set of routines and procedures for product design, manufacturing, delivery, service, and support. Standardization ensures that customers consistently get the same product or service initially promised. ISO 9000 specifies a list of detailed requirements that need to be satisfied and without which the work is rejected. These requirements nurture a culture that supports attention to detail and adherence to rules and procedures.

Quality Improvement Teams. The team has become the building block of most QI initiatives (Banker et al. 1996) in response to increasing complexity and change. "Instead of the individual being responsible for separate pieces of work, groups of individuals come together to combine their effort, knowledge, and skills to achieve shared goals" (West 2004, p. 138). QI teams often operate as self-managed teams with considerable autonomy in determining the QI process from idea generation to idea implementation and improvement (Banker et al. 1996, Hackman and Wageman 1995). Recent studies demonstrated that QI teams foster cross-fertilization of ideas, which increases the variance in ideas, leading to more innovation than might have occurred if individuals worked alone (Lewis et al. 2002, Lovelace et al. 2001). Therefore, QI teams can create a culture that promotes innovation. The element of idea implementation in the QI process requires attention to detail as well. Yet in the context of QI initiatives, the contribution of QI teams over standards and procedures fostered by ISO 9000 is mainly in emphasizing the value of innovation.

Goal Setting. The goal-setting theory proposed that having specific and challenging goals motivates employees toward high performance levels, as long as employees are committed to the goals and get feedback on performance (Erez 1995, Locke and Latham 2002). The setting of goals transforms symbolic messages of QI initiatives into concrete and measurable outcomes of goal accomplishment (Pritchard et al. 1988). In the context of QI initiatives, goals are set to minimize defects and rework. Nonetheless, goals can also be set to enhance innovation (Shalley 1991). New goals may lead to a change in preferences and values (Schein 1996). Setting QI goals may enhance a culture of attention to detail and innovation.

Coaching and Communication by Top Management. Leaders communicate their vision to their followers through their written and oral messages and by serving as role models who practice their vision. Leaders' written and oral messages convey the values and priorities that shape the organizational culture and lead to performance improvements when supported by the leaders' personal commitment and behaviors (Zbaracki 1998). For example, Motorola's former CEO, Bob Galvin, made a habit of making quality the first item on the agenda of executive staff meetings and leaving the meeting before the discussion of financial issues (Evans and Dean 2000, p. 276). Leaders can blend styles of emphasizing attention to detail and innovation (Lewis et al. 2002).

While standard rules and procedures require attention to detail and teamwork enhances learning and innovation, goal setting and coaching and communication by top management could direct employees' behavior toward both innovation and attention to detail.

Hypothesis 1. *The four QI practices will positively influence the cultural values of innovation and attention to detail in the following way*: *ISO* 9000 *will affect the value of attention to detail*, *whereas QI teams will affect innovation. QI goals and coaching and communication by top management will have an effect on both attention to detail and innovation.*

Effects of QI Practices and Attention to Detail and Innovation on Quality and Productivity Performance

Following Argote (1999), who recommended further exploring how organizations can benefit from the principles of standardization and heterogeneity, we examined the effect of QI practices on these two cultural values and on performance. QI theory suggests that each of the four QI practices—ISO 9000, QI teams, quality goals, and coaching and communication by top management—has a direct, positive effect on performance quality (Hackman and Wageman 1995). In addition, because quality and productivity performance improvements have similar roots (Garvin 1988), the four QI practices should also positively affect productivity. Productivity reflects the ratio of defect-free output to inputs and thus, improvement in quality positively affects productivity (Erez 1990). Less rework means more time devoted to manufacturing acceptable products, and less scrap means fewer wasted materials; thus, generally, a positive relationship exists between quality and productivity. Therefore we hypothesize the following.

Hypothesis 2. *QI practices*, *consisting of ISO* 9000, *QI teams*, *quality goals*, *and coaching and communication by top management*, *will have positive effects on performance quality and productivity.*

Cultural values represent "the way things are done around here" (Bates et al. 1995, p. 1570), and thus, they reorient activities and lead to engagement in activities that are aligned and congruent with them (Barney 1986, Denison and Mishra 1995, Weick 2000). Culture serves as a cognitive framework shared by the members of the organization and guides their interpretations and responses to situations (Schein 1996).

Shared understanding of the importance of attention to detail reinforces new forms of behavior that emphasize conformity to rules and procedures, precision, and accuracy, which are important for quality and productivity performance improvement. Shared understanding of the importance of innovation reinforces new forms of behavior that emphasize responsiveness to new opportunities and experimentation of new ideas that lead to improvement of quality and productivity. We therefore hypothesize as follows.

Hypothesis 3. *Both the cultural values of attention to detail and innovation will positively affect performance quality and productivity.*

Integrating the above three hypotheses generates a fourth hypothesis on the mediation effect of the cultural values of attention to detail and innovation. In consequence, to the extent that attention to detail and innovation account for the relation between the QI practices and quality and productivity performance, these cultural values may be said to function as mediators. QI practices affect the cultural values of innovation and attention to detail, and the latter affect performance quality and productivity, so we make the following hypothesis.

Hypothesis 4. *The cultural values of innovation and attention to detail will mediate the effects of the four QI practices on performance quality and productivity.*

Method

Participants

Participants were 425 production workers from all 18 departments of four plants that comprised one large organization. There were 130, 88, 134, and 73 employees in Plants 1, 2, 3, and 4, respectively. Between 16 and 28 employees worked in each of the 18 departments. Of the employees, 99% were men with an average tenure of 17 years and an average of 12 years of education.

The four plants operate in the motor vehicle parts manufacturing industry and focus on manufacturing, rebuilding, and assembly of metal parts into components and finished products. Each of the four plants produced different types of products:

- Plant 1—gearboxes, steering components, radiators, and axles
- Plant 2—components and finished products from rebuilt and assembled metal parts
- Plant 3—fuel and diesel engines
- Plant 4—electric engines and other vehicular electrical and electronic equipment.

Although they produce different products, the four plants use the same technologies (such as forging, stamping, bending, welding, and machining). Their manufacturing and assembly processes are labor intensive and repetitive and have not changed significantly in the last several years.

Research Design

This longitudinal intervention study consisted of five phases of four months each. The quality literature does not provide clear guidance regarding an appropriate period for analyzing the effect of a QI initiative (Hendricks and Singhal 2001). Nevertheless it is known that QI teams, for example, tend to solve a specific problem within 2–3 months (Evans and Dean 2000). Therefore, a four-month period seemed to be appropriate for assessing changes in the effects of the QI intervention.

The first phase served as the baseline. The intervention, which took place between Phases 2 and 5, involved implementation of four QI practices. These were as follows:

(1) The ISO 9002[1] Quality Assurance Standard. Implementation of ISO 9002 consists of the following activities: (a) Examination of the adequacy of work processes and methods for meeting product specifications, for example, relocation of inspection and test points and identification and calibration of test equipment. (b) Documentation of the work processes, work instructions, and quality assurance procedures. (c) Internal auditing conducted by quality assurance experts to verify that activities comply with the documentation. (d) Applying corrective and preventive actions in response to auditing reports.

(2) QI Teams. Each department formed one QI team consisting of all employees in the department. Altogether there were 18 departments, so there were 18 QI teams. Employees of each department participated in two training programs meant to turn them into a QI team—one in methods of quality improvement, such as statistical process control, and one for building interpersonal skills. Following the training programs, team members met once a week to review their team performance, make suggestions for improvement, and reach decisions related to performance improvement. Each team collected data regarding daily quality performance. Once a week that team received two types of feedback: (a) a graph displaying its quality performance in terms of the change in the percentages of defects relative to previous weeks, and (b) a Pareto chart of the main sources of defects. The graphs were publicly posted in the respective workstations. In addition, the teams received feedback from internal and external customers on product quality. These sources of information served as input for the teams' weekly meetings. Yet the teams did not set specific quality performance goals.

[1] ISO 9002 is the specific standard for production that is part of the general category of ISO 9000.

(3) Quality Goals. Each department participatively set a quality goal in terms of the percentage of defect reduction for the next period. This goal was portrayed on a graph posted at the workstation together with a graph on quality performance, which enabled the department members to review their performance relative to their goal. Under this condition, unlike the QI teams' condition, the department members were not trained to work as a QI team, and they did not acquire methods of QI toward goal attainment.

(4) Coaching and Communication by Top Management. Top management activities consisted of (a) serving on a steering committee that developed, directed, and evaluated the QI implementation; (b) serving as quality auditors; (c) implementing an "open door" policy allowing employees to discuss quality-related issues; (d) participating in training programs and QI team meetings; (e) granting QI recognition awards; (f) allocating time and other resources for QI implementation; and (g) publishing a new monthly quality bulletin, communicating quality-related issues and messages from the managers.

The Longitudinal Design

Table 1 portrays the longitudinal design of the study. Phase 1 served as the baseline, followed by the implementation of the four QI practices as follows.

In Phase 2, we implemented ISO 9002, which was mandatory, in all four plants. In addition to ISO 9002, in Plant 1 we implemented quality goals, in Plant 2 QI teams and quality goals, and in Plant 3 QI teams and coaching and communication by top management. In Plant 4 only ISO 9002 was implemented. Once a practice was implemented it continued to operate in all subsequent phases. In Phase 3, additional QI practices were introduced: Plant 1 had coaching and communication by top management; Plant 2 had none; Plant 3 had quality goals, thereby completing the implementation of all four practices in this plant; and Plant 4 had QI teams and quality goals. In Phase 4, the additional QI practices were QI teams in Plant 1, completing the implementation of all four practices in this plant; coaching and communication by top management in Plant 2, completing the implementation of all four QI practices in this plant. No additional practices were implemented in Plant 4. In Phase 5, in Plant 4, coaching and communication by top management was implemented, completing the implementation of all four practices in all four plants. The different order of implementation enabled us to partially test for the independent effects of the practices and determine whether a better sequential order of implementation exists.

Table 1 Research Design—Schedule of Implementation

	Plant 1	Plant 2	Plant 3	Plant 4
Phase 1(baseline)				
ISO 9002	−	−	−	−
QI teams	−	−	−	−
Quality goals	−	−	−	−
Coaching and communication by top management	−	−	−	−
Phase 2				
ISO 9002	+	+	+	+
QI teams	−	+	+	−
Quality goals	+	+	−	−
Coaching and communication by top management	−	−	+	−
Phase 3				
ISO 9002	+	+	+	+
QI teams	−	+	+	+
Quality goals	+	+	+	+
Coaching and communication by top management	+	−	+	−
Phase 4				
ISO 9002	+	+	+	+
QI teams	+	+	+	+
Quality goals	+	+	+	+
Coaching and communication by top management	+	+	+	−
Phase 5				
ISO 9002	+	+	+	+
QI teams	+	+	+	+
Quality goals	+	+	+	+
Coaching and communication by top management	+	+	+	+

+ implementation; − no implementation.

Measures

Independent Variables. The four QI practices—ISO 9002, QI teams, quality goals, and coaching and communication by top management—served as independent variables. They were coded as "0" when not yet implemented in the plant and as "1" when implemented.

Evaluation of the QI program implementation. Two parallel panels of two external experts each monitored and evaluated the implementation of the four QI practices in all 18 departments, based on existing documents and personal interviews. The panels used an evaluation form, based on Baldrige criteria (2001) consisting of 19 questions organized in four sections, each related to one of the four QI practices, using a Likert-type scale between 0 and 5. For example, for the ISO 9002 implementation—"Updated documentation (such as technical specifications, work instructions, and procedures) is available for all the departmental activities and assignments"; for QI teams—"Team members meet once a week to review their work methods and team performance. They make suggestions for corrective actions, prevention actions, and other improvements based on brainstorming and data analyses"; for quality goals—"Employees are familiar with the quality goals"; and for coaching and communication by top management—"The plant and the department managers communicate quality-related issues and messages."[2] The external evaluations took place during the first, third, and fifth implementation phases.

The mean evaluation score per department per implemented QI practice ranged from 4.7 to 5 (SD from 0.0 to 0.2), compared to 0.5 to 1.1 (SD from 0.1 to 0.3) in departments in which the practice was not yet implemented. No significant differences in evaluation were found between departments in which the practice was implemented (F values between 0.21 and 0.65, $p > 0.1$). These findings suggest that the QI program implementation was as requested in all departments.

Dependent Variables. Two performance variables, cost of nonquality and productivity, were measured using departmental data accumulated through the organization's information system.

Cost of nonquality. This measure was calculated as the ratio between the extra hours invested to repair rejected products and the total work hours invested in defect-free products per day. Low values mean high quality. Data on cost of nonquality were collected daily by independent quality inspectors and fed into the information system database. We measured the accumulated cost of nonquality for each one of the five phases of the study. In addition, we collected data on the cost of appraisal (manufacturing inspection cost), prevention (cost of preparation of documentation, calibration, and training), and external failure (repairs at the customer's site and returns from customers).

Productivity. This was measured in each department as the ratio between the standard time per product, based on industrial engineering methods, and the actual time taken to produce/assemble the product (Knod and Schonberger 2001, p. 430). Every year the standard times were readjusted by about 3%, taking into consideration learning curves (readjustment was calculated every four months). Organizations vary tremendously in their readjusted rates (Argote 1999, p. 28), and the 3% was set based on the accumulated experience in productivity increases in the four plants. The overall productivity measure for each department consisted of the standard time per product multiplied by the number of defect-free products per day, divided by the department's total number of work hours per day. Productivity for each of the five phases was measured by the above index accumulated by the number of working days per phase. In addition, we assessed other productivity-related variables in each one of the five phases: (a) raw materials used in manufacturing each product, (b) energy used, (c) inventory cost (in dollars), (d) accident rate (the average number of accidents per employee), and (e) profit gain as a result of employees' suggestions.

[2] The complete questionnaire can be requested from the authors.

Mediating Variables—Organizational Culture. Two scales of six items each measured innovation and attention to detail using a seven-point Likert-type scale, based on O'Reilly et al. (1991). For example, items that assessed attention to detail: "Employees do not submit to a quality inspector a part that deviates slightly from the recommended standard size." "In the absence of an oil pump needed for completing the assembly, employees wait for a new pump rather than using the old one that does not meet the standards." Items that assessed innovation: "When a part for completion of assembly is missing, employees immediately suggest an alternative solution that enables the completion of the work plan." "Employees try new options, even at the possible risk of not meeting the deadline."

Prior to the beginning of the intervention, we conducted a pilot study on a small sample of 36 participants to test the clarity of the organizational culture questionnaire. The final questionnaire was administered at the end of each implementation phase to a sample of 25% of the employees in each department who were randomly selected in the Phase 1, and continued to respond throughout the other four implementation phases. The Cronbach's alpha coefficients of reliability in the five phases ranged between 0.81 and 0.89 for innovation and between 0.83 and 0.93 for attention to detail. Explanatory factor analysis (principal factor with varimax rotation) of the two measures resulted in two independent factors (item loadings ranged from 0.68 to 0.93; percentage of variance explained by attention to detail items was 40.9 and by innovation, 41.7).

Data Analysis

The four QI practices were implemented at the plant level ($N = 4$), whereas performance was measured at the departmental level ($N = 18$). Therefore, we used hierarchical linear models (HLM), which take into consideration the nested structure of departments within plants. Individual responses to the organizational culture questionnaire were aggregated to the departmental level. r_{wg}'s homogeneity coefficients of innovation and attention to detail were calculated for each of the 18 departments in each phase and ranged between 0.79 and 0.83 for innovation and between 0.80 and 0.84 for attention to detail in Phase 1, and between 0.88 and 0.94 for innovation and 0.91 and 0.97 for attention to detail in Phase 5. This justified the aggregation to the departmental level.

HLM was applied by formulating the cross-level relationships between departments and plants as two-level random intercept models (Bryk and Raudenbush 1992, pp. 84-86). Table 3 presents the seven HLM models. HLM also allowed us to analyze the effects of each of the five repeated measures within the departments and plants. For each practice, all five repeated measures were taken into consideration, comparing performance between the phases, before and after the implementation of each practice. Controlling for the time series interdependencies, the structure of the within-departmental error covariance matrix of the five times longitudinal measure was specified as repeated measures. Using likelihood-based criteria (Littell et al. 1996, pp. 92–102), the covariance structure selected to explain both the cost of nonquality and productivity (Models 3, 4, 5, 6, and 7 in Table 3) was the autoregressive order 1 (AR(1)). This structure has homogeneous variances and correlations that decline exponentially with distance. The correlation between measurements at times one and two is ρ, between measurements at times one and three is ρ^2, between measurements at times 1 and 4 is ρ^3, and so on. The unstructured (UN) covariance structure was selected for explaining the cultural values of attention to detail and innovation (Models 1 and 2 in Table 3) (Littell et al. 1996, pp. 99, 273).

The HLM equation for calculating the effects on cost of nonquality (Model 5 in Table 3) is

$$\begin{aligned}(\text{cost of nonquality})_{ijk} &= \beta_0+\alpha_i+\beta_1(\text{ISO 9002})_{ik}\\ &\quad+\beta_2(\text{QI teams})_{ik}+\beta_3(\text{goals})_{ik}\\ &\quad+\beta_4(\text{coaching \& communication})_{ik}\\ &\quad+\beta_5(\text{attention to detail})_{ijk}+\beta_6(\text{innovation})_{ijk}+\varepsilon_{ijk},\end{aligned}$$

where—

Plant: $i=1,\ldots,4$

Department: $j=1,\ldots,n_{18}$

Time: $k=1,\ldots,5$

β_0: The fixed part of the intercept

$\beta_l-\beta_6$: Fixed parameters

(Cost of nonquality)$_{ijk}$: Cost of nonquality of the jth department in the ith plant in the kth time period

(ISO 9002)$_{ik}$, (QI teams)$_{ik}$, (Goals)$_{ik}$, and (Coaching and communication by top management)$_{ik}$: The intervention in the ith plant in the kth time period

(Attention to detail)$_{ijk}$ and (Innovation)$_{ijk}$: The cultural value score of the jth department in the ith plant in the kth time period

α_i: The random intercept, which is typical of the plant: $\alpha_i \sim N(0, \sigma_\alpha^2)$

ε_{ijk}: The εs are random first-order autoregressive time processes $\varepsilon_{ijk} \sim N(0, \sigma^2)$

ρ: The parameter ρ stands for the correlation between adjacent observations in time within the same department

Coefficient estimations and the parameters are summarized in Table 3. The same procedure served for estimating the parameters in all seven models.

A comparison between Models 3 and 5 and between Models 4 and 6, given the results of Models 1 and 2, enabled us to identify mediating effects.

Results

Structure of Cultural Values

Confirmatory factor analysis tested the two-factor structure of the cultural values of attention to detail and innovation that was found in the exploratory factor analysis. First we tested the two-factor model, allowing the two attributes to covary. Then we compared this model to a nested alternative of one factor by setting a covariation between the two variables equal to one, representing one continuum (Lewis et al. 2002). Results demonstrated that the two-factor model yielded a good fit ($\chi^2 = 350.46$, $df = 59$, goodness-of-fit index [GFI] = 0.92, comparative fit index [CFI] = 0.90, root mean-square error of approximation [RMSEA] = 0.05). Item loadings were significant ($p < 0.01$). In contrast, the one-factor model yielded a poor fit ($\chi^2 = 1017.72$, $df = 60$, GFI = 0.74, CFI = 0.65, RMSEA = 0.18). A chi squared difference test showed that the fit of the nested model was significantly worse than that of our two-factor model ($\Delta\chi^2 = 667.26$, $df = 1$, $p < 0.001$). Thus, our findings provide evidence that the cultural values of innovation and attention to detail are two distinct values rather than one continuum. Factor covariation between attention to detail and innovation was not significant.

Performance Outcomes

Overall cost of nonquality dropped from 23.5% in Phase 1 to 2.4% in Phase 5. External failure decreased from 4.2% to about 1% of the organizational output. All four plants were granted the ISO 9002 certification at the end of the QI intervention. Departmental productivity increased from 100.4 to 104.5.[3] Altogether,

[3] The additional measures related to the cost of quality were cost of appraisal—did not change (ranged between 1,550 and 1,850 hours per plant in each phase of the study); prevention activities—all conducted during working hours, with most training done in house, provided by company trainers. Related productivity measures also improved consistently throughout the five-phase period: Energy use decreased slightly (ranged from 1,460 to 1,820 Megawatt hours annually per plant); use of raw materials decreased by 4%; inventory costs decreased by 11%. Profit gain as a result of employees' suggestions multiplied by four. The accident rate decreased by 62%.

Table 2 Mean, Standard Deviation, and Correlation—First and Last Phases[a]

	N[b]	First phase		Last phase		1	2	3	4
		Mean	SD	Mean	SD				
1. Attention to detail	18	4.6	0.5	6.5	0.2		0.1	−0.4*	0.31*
2. Innovation	18	4.7	0.6	6.3	0.2	0.02		−0.35*	0.35*
3. Cost of nonquality	18	23.5	5.9	2.4	1.3	−0.4*	−0.35*		−0.28*
4. Productivity	18	100.4	1.6	104.5	1.4	0.3*	0.32*	−0.32*	

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.
[a] Correlations between variables before implementing the QI initiative are below the diagonal; correlations after implementation (last phase of the study) are above the diagonal.
[b] in each phase.

the QI intervention had a very positive effect on performance quality and productivity.

Table 2 presents the means, standard deviations, and intercorrelations among all the research variables in two phases—baseline (below the diagonal) and last phase (above the diagonal). There was no significant correlation between the cultural values of innovation and attention to detail, but the two significantly correlated with the two performance measures of cost of nonquality and productivity.

Hypotheses Testing

In line with Hypothesis 1, Models 1 and 2 tested for the effects of the four QI practices and the random effects of plant, department, and time on the cultural values of innovation and attention to detail. The results demonstrated that ISO 9002 had a significant and positive effect on attention to detail (see Table 3), but a negative effect on innovation. QI teams and quality goals had positive and significant effects on innovation only. The findings partially supported Hypothesis 1: Coaching and communication did not have a significant effect on either attention to detail or innovation, over and above the other effects. Quality goals did not have a significant effect on attention to detail, over and above the other effects. ISO 9002 had a significant negative effect on innovation.

In line with Hypothesis 2, Models 3 and 4 tested the effects of the four QI practices and the random effects of the plant, department, and time on the two performance measures. Although Hypothesis 2 predicted significant effects of all four QI practices on the two performance measures, the QI practices had differential effects on performance: QI teams, quality goals, and coaching and communication by top management significantly affected the cost of nonquality, whereas only ISO 9002 significantly affected productivity, over and above the other effects. These findings partially supported Hypothesis 2.

Models 5 and 6 tested the effects of the four QI practices, attention to detail and innovation, and the random effect of plant, department, and time on performance outcomes. The results supported Hypothesis 3, demonstrating significant effects of the two cultural values on the performance measures, over and above the effects of the four QI practices. Both cultural values led to lowering the cost of nonquality and improving productivity. Thus, the two cultural values complemented—rather than competed with—each other in their effects on the outcome variables.

The six models (Models 1–6) served to test the mediating effects of innovation and attention to detail on the relationship between the four QI practices and performance quality and productivity. The results partially supported Hypothesis 4: Innovation and attention to detail partially mediated the effect of ISO 9002 on productivity (the significant coefficient of 2.6, $p < 0.001$ in Model 4 decreased to 1.8, $p < 0.05$ in Model 6). ISO 9002 had a positive effect on attention to detail and the consequent productivity level, yet had a negative effect on innovation. Innovation, on the other hand, positively affected productivity. Hence we can say that ISO 9002 would have had a stronger effect on productivity if it had not impaired innovation.

QI teams and quality goals continued to have direct effects on cost of nonquality in the presence of the two cultural values, and thus there was no mediation effect. Yet the superiority of Model 5 over Model 3 ($\chi^2_2 = 55$, $p < 0.001$)[4] demonstrated that the additive effects of QI practices and culture could better explain performance quality than the effects of QI practices alone.

Cost of nonquality had a significant effect on productivity (see Model 7), a finding that lends support to the general proposition stated by the quality management approach, which asserts that quality has a positive effect on productivity.

In no models were there effects of plant, department, and time, over and above the effects of the four QI practices and of the cultural values. The four QI practices that were introduced in a sequential order overlapped the time effect. It should be noted that the

[4] This measure is the absolute difference between −2 Res Log Likelihood in Model 3 and −2 Res Log Likelihood in Model 5 (506–451); the same applies to Models 4 and 6 (303–290).

Table 3 Result of Hierarchical Models Testing the Effect of Quality Improvement Initiative and Organizational Values on Performance

	Model 1 Attention to detail	Model 2 Innovation	Model 3 Cost of nonquality	Model 4 Productivity	Model 5 Cost of nonquality	Model 6 Productivity	Model 7 Productivity
Fixed effects							
(β_0) Intercept	5.3*** (0.1)	6.2*** (0.16)	3.5 (2)	105.4*** (0.44)	1.8 (8.33)	103.2*** (2.5)	101.1*** (2.4)
Quality improvement initiative							
(β_1) ISO 9002	0.5* (0.26)	−0.9** (0.3)	1.1 (1.94)	2.6*** (0.6)	−3.11 (2.7)	1.8* (0.8)	1.7* (0.8)
(β_2) QI teams	0.2 (0.2)	1.15*** (0.25)	−7.4*** (2.17)	0.04 (0.65)	−7.9*** (2.3)	0.27 (0.72)	0.27 (0.73)
(β_3) Quality Goals	0.22 (0.13)	0.82*** (0.14)	−8.7*** (1.13)	0.61 (0.3)	−6.3*** (1.4)	0.06 (0.46)	0.06 (0.46)
(β_4) Coaching and communication by top management	0.05 (0.26)	−0.03 (0.3)	−4.9* (1.95)	0.46 (0.6)	−2.6 (2.1)	0.11 (0.6)	0.11 (0.6)
Organizational culture values							
(β_5) Attention to detail					−2.9* (1.26)	0.9* (0.4)	0.9* (0.4)
(β_6) Innovation					−2.8* (1.3)	1.2* (0.48)	1.2* (0.48)
(β_7) Cost of nonquality							−0.8* (0.13)
Random effects							
(σ_α^2) Plant	0.13 (0.2)	0.15 (0.18)	0.19 (0.22)	0.22 (0.23)	0.21 (0.19)	0.18 (0.21)	0.18 (0.21)
(σ^2) Department	0.03 (0.02)	0.02 (0.03)	0.04 (0.13)	0.16 (0.26)	0.28 (0.13)	0.15 (0.25)	0.15 (0.25)
(ρ) Time			0.09 (0.13)	0.11 (0.12)	0.22 (0.13)	0.12 (0.14)	0.12 (0.14)
N	90	90	90	90	90	90	90
−2 Res Log Likelihood	155	165	506	303	451	290	281

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$. Standard errors in parentheses. In Models 1 and 2, ρ is a matrix (see data analysis section) with values ranged from 0.01 to 0.09; none of these values was significant.

standard time component of the productivity measure was readjusted to account for learning. Therefore, to the extent that learning is captured by the time trend, learning does not seem to be a viable explanation for our results. The lack of plant effect means that the order of implementation of the QI practices had no effect.

Discussion

The QI intervention resulted in a remarkable improvement in performance quality—from a baseline level of 23.5% of the cost of nonquality to a level of only 2.4%. Moreover, there was no trade-off relationship between performance quality and productivity. The latter continued to increase, paralleling the increase in quality.

Analyzing the reasons that led to the success of the intervention illuminates a number of theoretical and practical considerations. First, from a theoretical perspective, this is the first study to introduce the cultural values of innovation and attention to detail into the QI paradigm. It is also one of the very few studies that provides empirical support to the coexistence of innovation and attention to detail. Second, the study demonstrated that the QI practices differentially affected innovation and attention to detail: ISO 9000 enhanced attention to detail, whereas QI teams and quality goals fostered innovation. Third, the study showed that the cultural values of innovation and attention to detail significantly influenced the cost of nonquality and productivity performances. Fourth, it demonstrated that the QI practices had a significant, direct effect on the two performance outcomes, and the cultural values added to these effects and partially mediated them.

The QI intervention provides an excellent context for both theory building and empirical testing of the coexistence paradigm, because quality improvement initiatives require both attention to detail and conformity to rules and standards, along with improvements and innovative solutions. Although theories of quality management advocate both values, in practice the implementation of ISO 9000 narrowly focuses on documentation, standardization, and conformity to rules and procedures. This focus has resulted in a culture of attention to detail—but not in a culture of innovation.

The present QI intervention has gone beyond ISO 9002 by implementing multiple practices. Whereas ISO 9002 drives behavior toward attention to detail, QI teams and quality goals push behavior toward innovation and improvement. In this context of multiple practices, innovation and attention to detail appeared as two independent factors both in the exploratory and confirmatory factor analyses. Our findings showed that the scores of the two cultural values increased over time, and they both lead to improvement in the two performance measures, supporting the coexistence approach. However, in a context that implements ISO 9002 only, there may be a trade-off relationship between attention to detail and innovation, as we found that ISO 9002 had a positive effect on attention to detail and a negative effect on innovation. Drawing upon these findings, it is reasonable to argue that multiple QI practices enable the emergence and the coexistence of both attention to detail and innovation, whereas ISO 9002 by itself leads to trade-off relationships. Thus, ISO 9000 is a necessary but insufficient condition for enhancing QI (Cole 1999), and QI interventions should consist of multiple practices, where some regulate attention to detail and exploitation of existing knowledge and others regulate exploration and innovation.

The practice of QI teams was geared toward innovation. It facilitated team learning, brainstorming of creative solutions, and utilizing the pool of mental resources of team members to develop innovative ways to improve quality. The longitudinal study enabled a continuous process of implementing, reevaluating, and improving the work methods and procedures that led to continuous quality and productivity improvement. As hypothesized, QI teams enhanced the value of innovation and contributed to performance quality directly and indirectly via their effects on innovation. Thus, our findings provided additional support to the research on team learning, demonstrating its effectiveness in additional work contexts (Amabile et al. 1996, Lewis et al. 2002, Lovelace et al. 2001, West 2002).

Setting quality goals was another effective practice that fostered a culture of innovation and resulted in QI. In contrast to our hypothesis, we found that quality goals did not affect attention to detail. Goals convey the importance of certain values and direct behavior toward goal accomplishment (Locke and Latham 2002). In the present study goals were set in terms of QI. Perhaps for this reason, QI goals promoted a culture of innovation—not attention to detail—and regulated behavior toward QI and not toward productivity. Our findings provide additional support for previous research, demonstrating that goals regulate behavior toward goal accomplishment: Creativity goals promoted creativity (Shalley 1991), goals for zero defects advanced quality (Erez 1990), and in the present case, quality improvement goals elevated quality over time.

Coaching and communication by top management, in contrast to what we hypothesized, did not significantly affect the two cultural values over and above the other QI practices. This may suggest that the other practices—ISO 9002, quality goals, and QI teams—in and of themselves conveyed the vision and mission of the top management. Leadership is reflected not only in what leaders communicate to their employees but also in the implementation of new managerial practices that serve to realize the vision (Schein 1996, Zbaracki 1998). QI initiatives may serve as a "substitute for leadership" by implementing managerial practices that affect organizational outcomes (Dean and Bowen 1994). Our findings support this view, demonstrating that while communication by top management, along with QI teams and goals, significantly influenced the cost of nonquality (Model 3), its effect on the cost of nonquality disappeared when the cultural values of innovation and attention to detail were added to the model (Model 5). The two cultural values that emerged in the presence of the other QI practices conveyed the message from top management, and communication by itself did not have any additional effect.

The pattern of relationships among QI practices, cultural values, and performance outcomes is intriguing. QI practices differentially affected attention to detail and innovation, but they also differentially affected performance quality and productivity. While ISO 9002 positively affected attention to detail and productivity (Models 1 and 6), QI teams and quality goals positively affected innovation and performance quality (Models 2 and 5). Nevertheless, both attention to detail and innovation positively affected performance quality and productivity. These relationships suggest that the multiple QI practices served different purposes and they elicited different cultural values. Yet both cultural values were necessary for performance quality and productivity. This pattern of relationships provides additional support to the coexistence of attention to detail and innovation in the context of multiple QI practices. The mediation effects that we proposed were not fully supported: There was a partial mediation of the ISO 9002—productivity relationships by attention to detail. Innovation and attention to detail significantly affected cost of nonquality over and above the effects of QI teams and quality goals, but they did not mediate the practices—the cost of nonquality relationships. These findings point to the importance of the role of organizational culture for QI initiatives. Nonetheless, QI practices by themselves are very powerful, and their effects on performance go beyond their effects on the organizational culture by providing the tools for performance improvement.

Based on the theory and the empirical findings, we concluded that QI interventions with multiple practices, which nurture the coexistence of innovation and attention to detail, result in QI along with high productivity.

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