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Gambi, Lillian Do Nascimento; Boer, Harry; Gerolamo, Mateus Cecilio; Jørgensen, Frances; Carpinetti, Luiz Cesar Ribeiro

Published in:
International Journal of Operations and Production Management

DOI (link to publication from Publisher):
10.1108/IJOPM-12-2013-0563

Publication date:
2015

Document Version
Publisher's PDF, also known as Version of record

International Journal of Operations & Production Manag...

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Lillian Do Nascimento Gambi Harry Boer Mateus Cecilio Gerolamo Frances Jørgensen Luiz Cesar Ribeiro Carpinetti

Received 23 December 2013
Revised 8 May 2014
31 August 2014
16 October 2014
12 November 2014
Accepted 16 November 2014

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Lillian Do Nascimento Gambi
Institute of Exact Sciences and Technology, Federal University of Viçosa, Rio Paranaíba, Brazil
Harry Boer
Center for Industrial Production, Aalborg University, Aalborg, Denmark
Mateus Cecilio Gerolamo
Department of Production Engineering, School of Engineering of São Carlos, University of São Paulo, São Carlos, Brazil
Frances Jørgensen
Department of Business Administration, School of Business and Social Sciences, Aarhus University, Aarhus, Denmark, and
Luiz Cesar Ribeiro Carpinetti
Department of Production Engineering, School of Engineering of São Carlos, University of São Paulo, São Carlos, Brazil

Abstract

Purpose – The purpose of this paper is to investigate if a firm's organizational culture affects the set of quality techniques it uses, and if these quality techniques affect the relationship between organizational culture and operational performance.

Design/methodology/approach – Based on data collected from 250 firms in Brazil and Denmark, structural equation modeling is used to investigate the relationship between organizational culture and the use of quality techniques, and its impact on operational performance. Four quality technique groups, four cultural profiles adopted from the Competing Values Framework and a set of operational performance indicators are used to operationalize the study.

Findings – Culture does not appear to be an unequivocal predictor of the use of quality techniques. Furthermore, while most quality technique groups contribute indirectly to the total effect on operational performance in the developmental, group and hierarchical cultures, the performance effects are insignificant for all four groups in the rational culture.

Practical implications – Managers need to be actively aware of the cultural characteristics of their organization before adopting quality techniques, in order to benefit most from the use of these techniques.

International Journal of Operations & Production Management
Vol. 35 No. 10, 2015
pp. 1460-1484

0144-3577
DOI 10.1108/IJOPM-12-2013-0563

The authors thank the CNPq – *Conselho Nacional de Desenvolvimento Científico e Tecnológico* (CNPq) for the financial support.

Originality/value – Most previous studies address the relationships between culture, quality management and performance at the level of quality practices. This study takes the unitarist-pluralist discussion to the level of quality techniques and extends that discussion to what should be its core, namely, the influence of quality techniques on the performance impact of culture.

Keywords Survey, Operational performance, Quality techniques, Structural equation modelling, Organizational culture

Paper type Research paper

1. Introduction

Most firms have adopted some form of quality management to improve quality and other indicators of performance. However, quality management initiatives do not always produce the intended results (Harari, 1993; Beer, 2003; Rad, 2006; Asif *et al.*, 2009). Sousa and Voss (2002) suggest that the differences between the results come from the universal approach to quality management, which assumes that the effects of quality management are context-independent. Many authors (Maull *et al.*, 2001; Sousa and Voss, 2002; Beer, 2003; Wu *et al.*, 2011) question this universal approach, and suggest that studying the impact of a firm's internal and external context would be useful to understand different results achieved from quality management initiatives, and possibly lead to the conclusion that there is no single best way of implementing and achieving benefits from quality initiatives (Wu *et al.*, 2011).

Organizational culture has been highlighted as one of the contextual variables that may explain the success rate of quality management (Asif *et al.*, 2009). Generally, there are two competing views on the role of culture in quality management. The unitarist view suggests that quality management is associated with a single, predominantly flexible and people oriented, culture. The pluralist view supports the idea that quality management should be built on heterogeneity of cultural dimensions. Prajogo and McDermott (2005) and Zu *et al.* (2010) test both views and conclude in favor of the pluralist view. That is, the adoption of different subsets of quality practices is determined by type of culture.

Although several studies have investigated the relationships between quality management, organizational culture and/or performance in case studies (e.g. Rad, 2006) or surveys (e.g. Prajogo and McDermott, 2005, 2011; Naor *et al.*, 2008; Kull and Wacker, 2010; Zu *et al.*, 2010; Baird *et al.*, 2011; Wu *et al.*, 2011), they focus primarily on what Dean and Bowen (1994) refer to as (quality) practices. However, although quality techniques also play an important role in the development and functioning of quality management (McQuater *et al.*, 1995; Handfield *et al.*, 1999; Tarí and Sabater, 2004; Lagrosen and Lagrosen, 2005; Tarí *et al.*, 2007), they have thus far not been empirically tested from a pluralist perspective.

In this context, the objective of this paper is to investigate whether the pluralist conclusion also hold if quality techniques are considered and the extent to which the set of quality techniques used by a firm affects the performance effects of its organizational culture.

2. Theoretical background and hypotheses

2.1 Quality management – definitions and elements

Many definitions of quality management have been proposed. Dean and Bowen (1994, p. 394) view total quality as "[…] an approach to management that can be characterized by its principles, practices, and techniques […] Each principle is implemented through a set of practices […] The practices are, in turn, supported by

[…] techniques." Flynn *et al.* (1994, p. 342) define quality management as an "[…] approach to achieving and sustaining high-quality output, focussing on the maintenance and continuous improvement (CI) of processes and defect prevention at all levels and in all functions of the organization […]." While, for example, Sousa and Voss (2002) and Gimenez-Espin *et al.* (2013) adopt this definition of quality management, most authors use some combination of the terms total, quality and management, often referring to Feigenbaum (1983) or Ishikawa (1985), without, however, defining their understanding of the concept properly. In this paper, we use the term quality management, adopting Flynn *et al.*'s (1994) definition. In addition, we build on Dean and Bowen's (1994) distinction between principles, practices and techniques. Examples of principles are customer focus, CI and teamwork (Dean and Bowen, 1994). Practices, such as leadership, engagement, teamwork, process management and people management and empowerment (Dean and Bowen, 1994; Prajogo and McDermott, 2005), have also been referred to as the "soft" (Rahman and Bullock, 2005) or "infrastructure" (Naor *et al.*, 2008) elements of quality management. Techniques include quality function deployment (QFD), failure mode and effects analysis (FMEA), brainstorming and statistical process control (Dean and Bowen, 1994; McQuater *et al.*, 1995; Handfield *et al.*, 1999), and have been referred to as the "hard" (Rahman and Bullock, 2005) or "core" (Naor *et al.*, 2008) elements of quality management.

2.2 Organizational culture and quality management

2.2.1 Models of organizational culture. Practitioners and researchers have increasingly become aware of the influence of the context in which quality management is implemented. In particular the role of culture has received considerable attention. The first articles addressing the relationship between organizational culture and quality management emerged in the early 1990s. Organizational culture affects the way an organization operates, influences people's decisions and behaviors and, in effect, its performance (Wu *et al.*, 2011), so much so that Schein (1984) states that culture is the key to organizational excellence.

In the quality management literature, several models of organizational culture have been used, including:

- Hofstede's model (Hofstede, 1980, 2001; Hofstede *et al.*, 2010).
- The personal, customer orientation, organizational and cultural issues (PCOC) model (Maull *et al.*, 2001).
- The organizational culture profile (OCP) (O'Reilly *et al.*, 1991).
- The competing values framework (CVF) (Quinn and Rohrbaugh, 1983).

Hofstede (1980) initially described culture in four dimensions (power distance, masculinity/femininity, individualism/collectivism and uncertainty avoidance). In later work, he added a fifth (long-term/short-term orientation; Hofstede, 2001) and a sixth dimension (indulgence/restraint; Hofstede *et al.*, 2010). Hofstede's work was used in various quality management studies, including those by Flynn and Saladin (2006) and Kull and Wacker (2010).

Maull *et al.*'s (2001) PCOC model was derived from Hofstede's (1980) work to provide firms with a cultural assessment tool to be used before implementing a quality management program. The model distinguishes four elements: the cultural element and

three elements that make up climate, namely, people outcomes, customer orientation and organizational issues. The authors applied their model in four case studies and conclude that it provides a useful basis for an a-priori cultural assessment.

The OCP model (O'Reilly *et al.*, 1991) was developed to assess the fit between the characteristics of a firm's individual employees and its organizational culture. Baird *et al.* (2011) used this model to study the association between organizational culture and the use of quality management practices.

In this paper , we adopt the CVF (Quinn and Rohrbaugh, 1983), which is not only a well-established (Naor *et al.*, 2008) and theoretically sound instrument (Zu *et al.*, 2010), but one that has also been relatively widely used in quality management studies (e.g. Prajogo and McDermott, 2005, 2011; Naor *et al.*, 2008; Zu *et al.*, 2010; Wu *et al.*, 2011; Gimenez-Espin *et al.*, 2013). The CVF is based on two main dimensions: the control-flexibility dimension reflects the extent to which an organization focusses on stability vs change whereas the internal-external dimension reflects the organization's focus on the internal organization vs the external environment. The juxtaposition of these two dimensions creates four cultural profiles: the group, developmental, hierarchical and rational profiles.

2.2.2 The unitarist vs pluralist discussion. There are two competing views on the relationship between culture and quality management. While the unitarist view suggests that quality management "is associated with a single 'homogeneous' culture […] the pluralist view […] supports the idea of heterogeneity of various cultural dimensions on which TQM should be built" (Prajogo and McDermott, 2005, p. 1106). Prajogo and McDermott (2005) test the two views, operationalizing culture using the CVF and quality management through six practices (leadership, strategic planning, customer focus, information and analysis, and people and process management), and conclude that different subsets of practices are determined by different types of cultures, that is, in favor of the pluralist view.

2.3 Organizational culture, quality management and performance

Several studies link quality management and performance (e.g. Handfield *et al.*, 1999; Samson and Terziovski, 1999; Kaynak, 2003). Some studies take organizational culture into account in this context (e.g. Prajogo and McDermott, 2005, 2011; Naor *et al.*, 2008; Wu *et al.*, 2011; Baird *et al.*, 2011; Gimenez-Espin *et al.*, 2013).

Handfield *et al.* (1999) investigate the relationships between four quality tool groups (human resource, measurement, design and discipline tools) and a set of performance indicators, and demonstrate that quality tool groups affect different dimensions of quality performance (e.g. defects, scrap rates) and overall firm performance (e.g. market share, competitive position). Samson and Terziovski (1999) examine the relationships between quality management practices (leadership, people management, customer focus, strategic planning, information and analysis, process management) and operational performance (customer satisfaction, employee morale, productivity, output quality and delivery performance). Their results show that the "soft" elements of quality management (leadership, human resources management, customer focus) are stronger predictors of performance than systems and analytically oriented criteria (information and analysis, strategic planning, process analysis). Kaynak (2003) studies the relationships between seven quality management practices (management leadership, training, employee relations, quality data and reporting, supplier quality management, product/service design and process management) and their effects on

operational (i.e. inventory management and quality) performance and financial/market performance. Her study shows that some quality practices have a direct effect on performance, while others affect performance indirectly. Further, she demonstrates that the positive effect of quality management practices on financial/market performance is mediated through operational performance.

These and other studies show that quality management has a significant impact on performance (see Sila and Ebrahimpour, 2005 for an extensive overview of indicators of human resource, customer, organizational effectiveness, and financial and market results reported in the literature). However, according to some reports (e.g. Harari, 1993; Rad, 2006), only about one-third of firms have achieved improvements in quality, productivity and competitiveness with quality management initiatives. Considering that quality management may be contingent on context, researchers have begun to study the role of context and organizational culture in particular, as a potential explanation for these somewhat ambiguous findings.

For instance, Naor *et al.* (2008) study the association between culture and quality management practices, and the relationships between these two constructs and performance. They report significant relationships between organizational culture and "infrastructure" quality practices, and between these practices and performance. The relationships between culture and "core" quality practices and between these practices and performance are not significant. Prajogo and McDermott (2011) examine the relationships between organizational culture and performance (product quality, process quality, product innovation and process innovation), and find that the developmental culture is the strongest predictor of performance indicators related to product quality, product innovation and process innovation. The group culture predicts process quality and process innovation, while the hierarchical culture predicts only process quality. Finally, they find that the rational culture is related to product quality and process quality. Wu *et al.* (2011) investigate associations between organizational culture, quality culture, quality management practices and performance and conclude that quality exploitation practices are highly related to performance outcomes when a firm's quality culture is not a well-established part of its organizational culture. If, in contrast, the quality culture plays a dominant role in a firm's organizational culture, quality exploration practices are significantly associated with performance. Baird *et al.* (2011) investigate the relationships between four organizational culture dimensions (outcome orientation, attention to detail, teamwork/respect for people and innovation) and four quality management practices (quality data and reporting, supplier quality management, process management and product/service design), and the effect of these practices on operational performance (quality and inventory management performance). Their findings suggest that teamwork/respect for people, outcome orientation and innovation enhance the use of quality management practices. Considering that these dimensions are characteristics of the group, rational and developmental cultures, respectively, these findings confirm previous studies (particularly Naor *et al.*, 2008). Moreover, the authors conclude that supplier quality management, process management and product/service design do not affect quality performance. Finally, Gimenez-Espin *et al.* (2013) find that the group culture has no significant effect on the quality management practices leadership, quality information, process control, CI, training in quality tools, teamwork, supplier relationship and customer orientation, and that the effects of the rational and hierarchical cultures on quality management are negative. Beyond the four cultural profiles defined by the CVF, they propose a fifth profile, "culture for quality," which, falling between the

developmental and the group cultures, has a double orientation – external and internal, and promotes flexibility. Their results suggest that this culture is the most appropriate for quality management initiatives. Additionally, these authors report a significant positive effect of quality management on business performance, without, however, indicating how they operationalize business performance.

2.4 Contradictions in the literature

The meaning of quality management has changed over the course of time (e.g. Mehra *et al.*, 2001). Still, Sousa and Voss (2002) conclude that "[…] there is a substantial agreement as to the set of constructs classified under the [quality management] umbrella" (p. 94), and that quality management has "solid definitional foundations" (p. 94). At the same time, however, they urge researchers to "[…] strive for a standardization of definitional terms" (p. 91) and call for future studies to make explicit at what level (principles, practices or techniques) they are addressing quality management, in order to avoid conflicting results due to unclear levels of analysis.

The publications referred to above report research on the associations between and among organizational culture, quality management and performance. Some publications confirm each other; other publications arrive at different or even contradictory conclusions.

One of the causes of different and contradicting results is differences in the conceptualization, operationalization and/or measurement of the key constructs, and/or differences in analytical approaches. The articles of Prajogo and McDermott (2005) and Gimenez-Espin *et al.* (2013) serve to illustrate the problem: whereas Prajogo and McDermott (2005) find that the group culture is the most dominant among the cultural profiles they consider, Gimenez-Espin *et al.* (2013) report that this culture had no significant effect on quality management practices. Both studies operationalize culture using the CVF. However, Prajogo and McDermott (2005) take their departure in the Denison and Spreitzer (1991) version, and measure that model using five-point Likert scales. Gimenez-Espin *et al.* (2013) base their measurement on Cameron and Quinn (2006) and ask respondents to allocate 100 points among the four types of culture. Furthermore, even though both studies use five-point Likert scales to measure quality management, Prajogo and McDermott (2005) operationalize quality management using six constructs while Gimenez-Espin *et al.* (2013) use eight constructs. Some of these constructs seem to overlap; others are clearly different. Finally, Prajogo and McDermott (2005) use structural equation modeling (SEM) to analyze their data, while Gimenez-Espin *et al.* (2013) use hierarchical linear regression analysis. Similar problems may also lie behind the unitarist-pluralist discussion (Prajogo and McDermott, 2005).

The problems related to differences in conceptualization, operationalization, measurement and analytical method cannot be solved in one article, if at all. However, we can make progress with two other issues.

First, the unitarist-pluralist discussion is problematic. Although Prajogo and McDermott (2005) and Zu *et al.* (2010) conclude in favor of the pluralist view, they do not consider performance effects. However interesting the question may be whether there is a "one-to-one" or "several-to-many" relationship between culture and quality, the essence from a management theory perspective is whether all quality management principles, practices and techniques thrive in all cultures, or if firms need to seek fit between their culture and quality management system in order to achieve the best possible performance outcomes.

Second, most publications focus on quality management practices (e.g. Kaynak, 2003; Zu *et al.*, 2010; Baird *et al.*, 2011,). Very few articles consider quality techniques alone and

find positive performance effects (e.g. Handfield *et al.*, 1999). Some authors operationalize quality management using both practices and techniques. Within this category, mixed results are reported. Some studies (e.g. Ahire *et al.*, 1995; Samson and Terziovski, 1999; Naor *et al.*, 2008) suggest that "soft" or "infrastructure" elements can improve performance without the "hard" or "core" elements. Other studies (e.g. Dean and Bowen, 1994; Flynn *et al.*, 1994) conclude that the interplay between practices and techniques is essential to improve performance. Still other authors (e.g. Singh *et al.*, 2009) also include both practices and techniques in their quality management construct, but do not make a distinction between them in their analyses.

2.5 Objective and research questions

2.5.1 Objective. The previous discussion shows that there are various problems in the culture – quality management – performance literature. The remainder of this paper focusses on the unitarist-pluralist problem at the level of quality techniques. Quality techniques play an important role in the development of quality management principles (e.g. CI mindset, organization-wide involvement) and practices (e.g. teamwork, CI) (McQuater *et al.*, 1995; Tarí *et al.*, 2007), and in the improvement of performance (Handfield *et al.*, 1999; Tarí and Sabater, 2004). Assuming that culture is an antecedent for the adoption of quality techniques, we take the unitarist-pluralist discussion to that level, and first investigate if and how culture affects the use of quality techniques. Next, we investigate if and how organizational culture, quality techniques and the interaction between these constructs affect performance. In order to reduce the problem of producing findings that are different from previous findings simply due to differences in operationalization, existing scales are used as much as possible.

2.5.2 Research questions. We investigate two research questions. First, we take previous reports on the effects of organizational culture on the use of quality management practices to the level of quality techniques, and examine:

RQ1. Does a firm's organizational culture affect the set of quality techniques it uses?

Next, we also take the culture – quality management – performance discussion to the level of quality techniques and explore:

RQ2. Does the set of quality techniques used by a firm affect the relationship between its organizational culture and operational performance?

3. Research design

3.1 Operationalization

3.1.1 Quality techniques. This study operationalizes quality management using the following, commonly used quality techniques:

- Benchmarking – a technique used to identify and stimulate the adoption of best practices (Ungan, 2004).
- FMEA – a process for identifying possible defects before they occur, and finding, minimizing or even eliminating their causes and effects (Cassanelli *et al.*, 2006).
- QFD – a method aimed at translating customer demands into design targets and major quality assurance points to be used throughout the production phase (Akao, 1990).

- Brainstorming – used by groups to generate ideas about issues such as the potential causes of, and solutions for, a problem; aimed at tapping "the creativity of a group's members by explicitly ruling out the evaluation of members contributions to the list and actively encouraging building on others' ideas" (Hackman and Wageman, 1995).
- Kaizen event – a systematic improvement initiative, executed by a multidisciplinary group in a short period of time (Liker, 2004).
- 5S – implementing visual order, organization, cleanliness, standardization and CI of the work environment (Womack *et al.*, 1990).
- Visual quality information – creating and visualizing up-to-date quality information in the work place (Liker, 2004).
- Quality tools – techniques supporting process improvement, including problem identification, analysis and prioritization tools – e.g. Pareto analysis, Ishikawa diagram, histograms and PDCA (Ishikawa, 1985).
- SQC (statistical quality control) – used to detect causes of variation in manufacturing quality, provide useful information for product design and determine manufacturing capability (Modaress and Ansari, 1989).
- Performance measurement – the process of quantifying the efficiency and effectiveness of action (Neely *et al.*, 2005).
- Preventive maintenance – activities performed after a specified period of time or machine use, which rely on the estimated probability that the equipment will breakdown, but done before its occurrence (Wu and Zuo, 2010).
- Poka-yoke devices – reduce the likelihood of, or even avoid, defects by preventing, correcting or identifying human errors as they occur (Stewart and Grout, 2001).

Based on their characteristics, we categorized these techniques into four groups (see Table I).

The use of each of the quality techniques was operationalized in 35 items (see the Appendix) and measured on a five-point Likert scale ranging from 1 = "Strongly Disagree" to 5 = "Strongly Agree." For most items the survey instruments of Ahire *et al.* (1996), Flynn *et al.* (1994), Naor *et al.* (2008) and Zu *et al.* (2010) were used. Items not included in these instruments were operationalized using definitions found elsewhere in the literature.

3.1.2 Organizational culture. This study considers organizational culture as an antecedent of quality management (Maull *et al.* 2001; Prajogo and McDermott, 2005; Naor *et al.*, 2008). The CVF (Quinn and Rohrbaugh, 1983), adapted from Denison and Spreitzer (1991) and Cameron and Quinn (2006), was adopted to identify four cultural profiles (see Table II).

This framework has been used in many quality management studies (e.g. Prajogo and McDermott, 2005, 2011; Naor *et al.*, 2008; Zu *et al.*, 2010; Wu *et al.*, 2011). Based on these authors' survey instruments, 20 items were identified (see the Appendix) and measured on a five-point Likert scale ranging from 1 = "Strongly Disagree" to 5 = "Strongly Agree."

3.1.3 Performance. From the survey instruments reported by Samson and Terziovski (1999), Kaynak (2003), Naor *et al.* (2008) and Baird *et al.* (2011), six items were identified to measure operational performance (see the Appendix). As it is difficult

Quality technique groups	Characteristics	Examples
Goal setting	Techniques that emphasize product and process design based on best practices and customer needs and requirements. These techniques help an organization to set goals that lead to better results	QFD, benchmarking
Continuous improvement	Techniques that are people oriented and help the employees to use their knowledge to support continuous improvement effectively. These techniques emphasize openness, participation and contribute to employee involvement	Brainstorming, kaizen event, quality tools, 5S
Measurement	Techniques for measuring quality and providing information about the effectiveness of activities to reach quality goals. These techniques help an organization to take fast actions based on data, and promote alignment regarding the quality goals	Performance measurement, visual quality information
Failure prevention/ control	Techniques aimed at preventing quality variation and problems in the production process and, if problems occur, identifying their causes and eliminate them. These techniques contribute to a stable and controlled production flow	SQC, FMEA, poka-yoke devices, preventive maintenance

Table I.
Quality technique groups, characteristics and examples

	Organizational culture profiles			
Characteristics	Developmental culture	Group culture	Hierarchical culture	Rational culture
Orientation	Growth, stimulation, creativity and adaptation to the external environment	Flexibility and focus on internal organization. Concern with human relations	Internal efficiency, uniformity, coordination and evaluation	Productivity, performance, goal fulfillment and achievement
Core values	Creativity and variety	Belonging, trust and participation	Security, order, rules and regulations	Competition, and successful achievement
Leadership	Willing to take risks and able to develop a vision of future	Participative	Conservative and cautious, paying close attention to technical matters	Directive and goal oriented
Performance priorities	Growth, development of new market and resource acquisition	Development of human potential and member commitment	Control, efficiency and stability	Planning, productivity and efficiency

Table II.
Organizational culture profiles and their main characteristics

to collect objective performance data (Kaynak, 2003), a five-point Likert scale was used, with "Sometimes meets expectations/exceeds expectations" (customer satisfaction) and "Consistently increasing/consistently decreasing" (productivity, cost, time, two quality items) to describe the end points of the scales. In addition, an item "Not sure" was included to prevent forcing respondents to choose any of the other answers if they do not know how their firm is performing.

3.2 Research models and methods

We devised two research models. The first model, depicted in Figure 1, is related to *RQ1* and shows the relationships between the four cultural profiles and the four quality technique groups.

To explore *RQ2*, the model presented in Figure 2 was devised. In this model there are two direct effects on "performance," one from "OCPs" (path (a)) and one from "quality technique groups" (path (c)). The indirect effect of culture on performance (path (b)→(c)) was investigated by forming pairs of cultural profiles and quality technique groups.

SEM was used to examine the two models. SEM allows the evaluation of entire models while providing statistical efficiency (Hair *et al.*, 2009; Kline, 2011). Following Hair *et al.* (2009), we first analyzed the measurement and then the structural models. Maximum likelihood estimation was used as the estimation procedure.

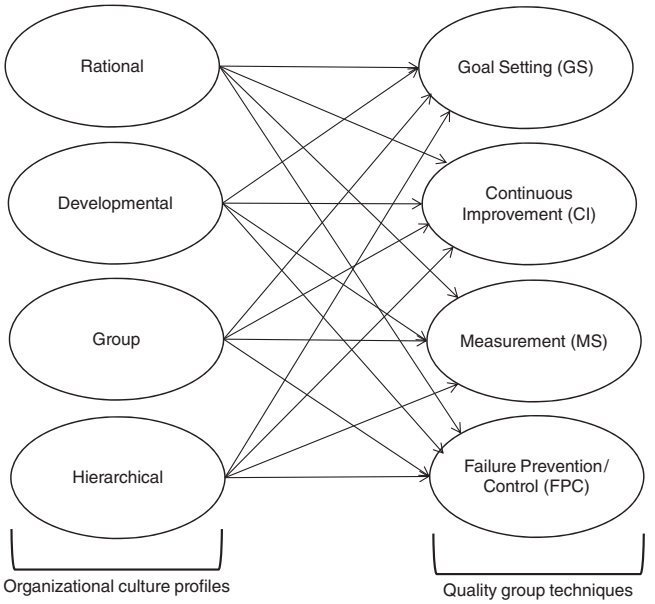

Figure 1.
Structural model of the relationships between OCPs and quality technique groups

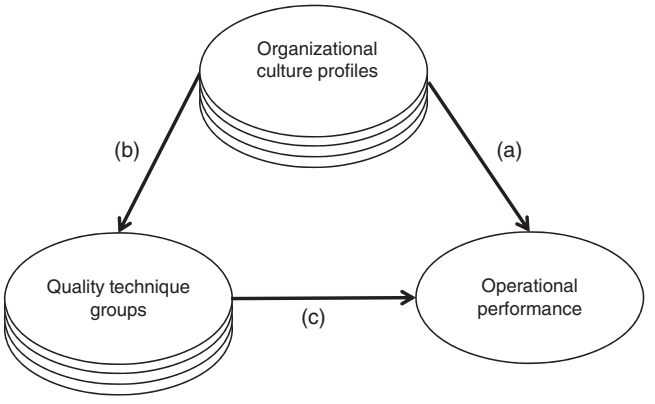

Figure 2.
Structural model of the relationships between culture, quality and performance

3.3 Sample demographics

Data for this study were drawn from a web-based questionnaire e-mailed to a random sample of 1,761 (actually 2,066; 305 e-mails bounced back) Brazilian and Danish manufacturing firms (SIC codes 20-39) in 2012/2013. The response rate was 14.2 percent (250 firms). The e-mail contained a link to the questionnaire embedded in a text explaining the research. Furthermore, following Frohlich's (2002) suggestions, university logos were used on the survey to endorse the research, multiple waves of mailings were sent and a report with the results was offered.

The early and late responses were used to estimate late-response bias (cf. Kaynak, 2003). Independent *t*-tests on the Brazilian and Danish subsamples did not indicate a significant difference between the two response waves. In addition, 17 firms were contacted by e-mail or phone to verify why they chose not to participate in the study. The main reasons mentioned were lack of time or interest.

The proportions of Brazilian (52.8 percent) and Danish (47.2 percent) respondents are nearly equal. Only the questionnaires returned without missing values were considered. The number of "Not sure" answers was small (below 2 percent). These answers were treated as missing points and replaced by medians. The unit of analysis is the manufacturing plant. Most respondents (over 80 percent) are quality or production managers. As to organizational size, 18.0 percent of the firms have 500 employees or more, 44.5 percent between 100 and 499 employees, 35.1 percent between 20 and 99 employees and 2.5 percent fewer than 20 employees.

4. Results

4.1 Reliability and validity

The survey scales are reflective, that is, the latent constructs (organizational culture, quality techniques, operational performance) reflect the measured variables (Hair *et al.*, 2009). The reliability of the scales was assessed using Cronbach's α. One variable from the hierarchical culture did not contribute to reliability and was dropped from the scale. With all Cronbach's α's $\geqslant 0.69$ (Table III), the other scales had acceptable reliability levels (Tabachnick and Fidell, 2007; Hair *et al.*, 2009) without dropping any variable. In order to verify that each measure represents only one construct, a test of discriminant

Table III. Bivariate correlations, mean values, standard deviations and Cronbach's α's for the constructs

Constructs	1	2	3	4	5	6	7	8	9	Mean	SD	Cronbach's α
1. Hierarchical culture	1									15.53	2.82	0.75
2. Group culture	0.58**	1								19.56	3.92	0.86
3. Rational culture	0.64**	0.60**	1							17.80	3.65	0.76
4. Developmental culture	0.49**	0.70**	0.63**	1						17.00	4.00	0.82
5. Goal setting	0.62**	0.74**	0.65**	0.70**	1					22.24	4.55	0.84
6. Continuous improvement	0.59**	0.68**	0.68**	0.63**	0.80**	1				34.79	7.75	0.91
7. Measurement	0.57**	0.43**	0.61**	0.42**	0.64**	0.73**	1			30.80	6.17	0.87
8. Failure prevention/ control	0.62**	0.61**	0.65**	0.55**	0.75**	0.82**	0.74**	1		38.06	8.72	0.90
9. Performance	0.42**	0.47**	0.48**	0.42**	0.47**	0.50**	0.46**	0.48**	1	21.26	3.19	0.69

Notes: $n = 250$. $^{**}p < 0.01$

validity was performed by comparing the bivariate correlations and the coefficients' reliability (cf. Kaynak, 2003). An instrument has discriminant validity if the bivariate correlations are smaller than the reliability coefficients. Table III shows that this is the case for all measures.

Performed in PASW Statistics 17, descriptive, bivariate analysis and homogeneity of variance tests were used to check normality, linearity and homoscedasticity. None of these analyses indicated statistically significant violations. The variance inflation factor (VIF) was calculated to assess multicollinearity. The largest VIF value among the independent variables is 9.5, which is below the threshold of 10.0 (Kutner *et al.*, 2004).

Three confirmatory factor analyses were performed separately to verify convergent validity and the overall fit indices of the measurement models. Item loadings were used to check convergent validity. High-convergent validity requires each item's coefficient to be greater than twice its standard error (*t*-value) (cf. Kaynak, 2003). The results indicate that the data have convergent validity. Measures of the overall goodness-of-fit indices that are commonly used in the literature (RMSEA, χ^2/df, CFI, IFI and TLI) were calculated in IBM® SPSS® Amos 20. As a guideline, RMSEA < 0.05 (good model fit), $0.05 <$ RMSEA < 0.08 (reasonable model fit) and RMSEA > 0.08 (poor model fit) were adopted. Furthermore, a normed χ^2 (χ^2/df) smaller than 2.0 is considered very good; between 2.0 and 3.0 is good; between 3.0 and 5.0 is acceptable (Hair *et al.*, 2009). Incremental fit indices (CFI, IFI and TLI) range from 0.0 (no fit) to 1.0 (perfect fit) (Tabachnick and Fidell, 2007; Hair *et al.*, 2009). Table IV shows good fit of the measurement models to the data.

4.2 Tests of the structural models

4.2.1 The association between organizational culture and the use of quality techniques. The model shown in Figure 1 was used to investigate *RQ1*, i.e. does a firm's organizational culture affect the set of quality techniques it uses? With four times four relationships, 16 paths from cultural profiles to quality technique groups were estimated. After deletion of the three insignificant paths ($p > 0.1$), the overall statistics for the model retained are $\chi^2/df = 2.04$, CFI $= 0.83$, IFI $= 0.83$, TLI $= 0.82$ and RMSEA $= 0.06$, which suggest satisfactory model fit. Figure 3 shows the significant paths and their path coefficients.

The relationship between organizational culture and quality techniques vary across different cultural profiles and quality technique groups:

- The rational culture predicts the use of all quality technique groups: goal setting (GS), CI, measurement (MS) and failure prevention/control (FPC).

Overall goodness-of-fit measures	Organizational culture profiles	Quality technique groups	Operational performance
Normed χ^2 (X^2/df)	2.07	1.70	1.15
Comparative fit index (CFI)	0.93	0.93	0.99
Incremental fit index (IFI)	0.93	0.93	0.99
Tucker-Lewis index (TLI)	0.91	0.92	0.99
Root mean square error of approximation (RMSEA)	0.06	0.05	0.02

Table IV. Overall goodness-of-fit measures for measurement models

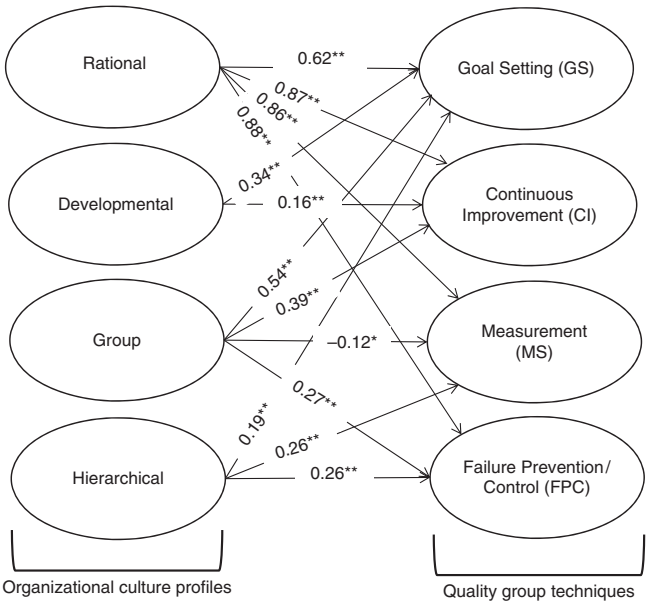

Figure 3.
Significant relationships between organizational cultural profiles and quality technique groups

- The developmental culture is positively related to GS and CI. The path coefficients from this culture to MS and to FPC techniques are insignificant ($p > 0.1$).
- The group culture is positively related with the use of GS, CI and FPC techniques. The association with MS techniques is negative. Thus, the stronger the characteristics describing this culture, the lower the use of MS techniques.
- The hierarchical culture is positively associated with the use of GS, MS and FPC techniques. The path coefficient from this culture to CI techniques is insignificant ($p > 0.1$).

While the rational culture is associated with each of the four quality technique groups and is a stronger predictor of each of these groups than any of the other cultural profiles. The other cultures predict the use of only two or three of quality technique groups. Apart from the rational culture, the group culture is the strongest predictor of GS, CI and FCP techniques. The hierarchical culture is the second strongest predictor of MS techniques.

4.2.2 The associations between organizational culture, quality techniques and performance. The model depicted in Figure 2 was used to investigate *RQ2*, i.e. does the set of quality techniques used by a firm affect the relationship between its organizational culture and operational performance? With four cultural profiles and four quality technique groups, sixteen models were tested. The overall model statistics show a good model fit ($\chi^2/df < 2.12$, CFI > 0.90, IFI > 0.90, TLI > 0.88 and RMSEA < 0.07).

Table V displays the direct effects of the cultural profiles (path (a) in Figure 2) and the quality technique groups (path (c)), the indirect effects of organizational culture (path (b)→(c)), as well as the total effect. The results show that quality techniques affect the relationship between organizational culture and operational performance. The performance

	Developmental culture		Group culture		Hierarchical culture		Rational culture	
	Paths	Effect	Paths	Effect	Paths	Effect	Paths	Effect
Goal setting	D→P	0.24^{ns}	G→P	0.39**	H→P	0.34**	R→P	0.65***
	D→GS	0.83***	G→GS	0.85***	H→GS	0.79***	R→GS	0.83***
	GS→P	0.34*	GS→P	0.21^{ns}	GS→P	0.27*	GS→P	0.01^{ns}
	D→GS→P	0.29*	G→GS→P	0.18^{ns}	H→GS→P	0.21*	R→GS→P	0.01^{ns}
	Total effect	0.29*	Total effect	0.39*	Total effect	0.55*	Total effect	0.65***
	Full mediation		*No mediation*		*Partial mediation*		*No mediation*	
Continuous improvement	D→P	0.17^{ns}	G→P	0.26**	H→P	0.26*	R→P	0.58**
	D→CI	0.75***	G→CI	0.77***	H→CI	0.74***	R→CI	0.87***
	CI→P	0.48***	CI→P	0.40***	CI→P	0.41***	CI→P	0.09^{ns}
	D→CI→P	0.36***	G→CI→P	0.31***	H→CI→P	0.30***	R→CI→P	0.08^{ns}
	Total effect	0.36***	Total effect	0.57**	Total effect	0.56*	Total effect	0.58**
	Full mediation		*Partial mediation*		*Partial mediation*		*No mediation*	
Measurement	D→P	0.34***	G→P	0.42***	H→P	0.39***	R→P	0.61***
	D→MS	0.52***	G→MS	0.46***	H→MS	0.69***	R→MS	0.78***
	MS→P	0.36***	MS→P	0.34***	MS→P	0.25**	MS→P	0.04^{ns}
	D→MS→P	0.19***	G→MS→P	0.16***	H→MS→P	0.17**	R→MS→P	0.04^{ns}
	Total effect	0.53***	Total effect	0.58***	Total effect	0.56**	Total effect	0.61***
	Partial mediation		*Partial mediation*		*Partial mediation*		*No mediation*	
Failure prevention/ control	D→P	0.24**	G→P	0.30***	H→P	0.25^{ns}	R→P	0.54***
	D→FPC	0.68***	G→FPC	0.72***	H→FPC	0.80***	R→FPC	0.82***
	FPC→P	0.42***	FPC→P	0.37***	FPC→P	0.39**	FPC→P	0.15^{ns}
	D→FPC→P	0.29***	G→FPC→P	0.27***	H→FPC→P	0.31**	R→FPC→P	0.12^{ns}
	Total effect	0.53**	Total effect	0.57***	Total effect	0.31**	Total effect	0.54***
	Partial mediation		*Partial mediation*		*Full mediation*		*No mediation*	

Notes: GS, Goal Setting techniques; CI, Continuous Improvement techniques; MS, Measurement techniques; FPC, Failure Prevention/Control techniques; ns, not significant ($p > 0.1$). *$p < 0.1$; ** $p < 0.05$; ***$p < 0.01$

Table V.
Performance effects of organizational cultures and quality techniques

effects vary across the pairs of cultural profiles and quality technique groups. In firms with a rational culture, the performance effects of the quality technique groups are insignificant, that is, culture explains 100 percent of the performance effects.

5. Discussion

5.1 RQ1: the association between organizational culture and the use of quality techniques

As Figure 3 shows, a firm's organizational culture affects the set of quality techniques it adopts. More specifically, stronger relationships were found between the rational culture, which focusses on the external environment and is control oriented, and all groups of techniques than for any of the other cultural profiles. This finding is not surprising for the measurement (MS), FPC and GS techniques, as these techniques support core characteristics of the rational culture, which include task focus, achievement, clarity, competition, directive and goal-oriented leadership, and efficiency and productivity (Denison and Spreitzer, 1991; Prajogo and McDermott, 2005, 2011; Cameron and Quinn, 2006; Zu *et al.*, 2010). The strong association with CI techniques is interesting. As these techniques are highly related to people involvement (Glover *et al.*, 2013), the association between the group culture and CI techniques should be expected to be relatively stronger than the relationship between the rational culture and this group of quality techniques. This finding demonstrates that control and people-

orientation can coexist in harmony at the level of both quality practices (Prajogo and McDermott, 2005) and techniques.

The data also suggest a positive association between the developmental culture, which focusses on the external environment and are flexibility oriented, and the use of GS techniques such as QFD and benchmarking. The relationship with CI techniques is also positive, but weaker. The relationships with the MS and FPC groups are insignificant. These findings, too, are consistent with the characteristics of this culture, which is oriented toward flexibility and adaptation to the external environment, innovation and creativity, entrepreneurship and leadership, that is, willing to take risks (Denison and Spreitzer, 1991; Prajogo and McDermott, 2005, 2011; Cameron and Quinn, 2006; Zu *et al.*, 2010).

The group culture, which focusses on the internal organization and is flexibility oriented, is positively associated with the use of GS, CI and FPC techniques. The association with MS techniques is negative. Thus, the stronger the characteristics describing this culture, the lower the use of MS techniques. Key characteristics of the group culture include teamwork, participation and belonging, empowerment and trust, concern with human relations, participative leadership, and development of human potential and member commitment (Denison and Spreitzer, 1991; Prajogo and McDermott, 2005, 2011; Cameron and Quinn, 2006; Zu *et al.*, 2010). Considering these characteristics, the positive association with the GS and CI techniques and the negative association with the MS techniques should be expected. The positive relationship between the group culture and FPC techniques is more surprising. Taken together, these findings also suggest that firms with a group culture do use people-oriented techniques (CI group), and also more planning (GS group) and control-oriented techniques (FPC group), but stay away from the "hardest" tools, namely, MS techniques.

The hierarchical culture, which is control oriented and focusses on the internal organization, does not have a significant relationship with CI techniques. This finding can be explained by the fact that this culture is characterized by a focus on internal efficiency and predictable outcomes, control, stability, order and uniformity, all of which are supported by formalization in the form of rules and regulations, and centralized, technically oriented "leadership" (Denison and Spreitzer, 1991; Prajogo and McDermott, 2005, 2011; Cameron and Quinn, 2006; Zu *et al.*, 2010). In such a setting, the use of GS and, especially, MS and FPC techniques, should be expected to prevail. The statistical results clearly support this suggestion.

Thus, a rational culture functions as should be expected, that is, rationally, by relying heavily on (any) tools and techniques. *Mutatis mutandis* the same holds for the group culture, which relies on the "softer" techniques GS and CI, less so on FPC, and not on MS techniques. The hierarchical culture tends to use GS, MS and FPC techniques. Finally, the developmental culture supports the use of GS and CI techniques.

Therefore, the set of quality technique groups adopted by each of the four cultural profiles and the magnitude of the culture-techniques relationships vary, which shows that the culture of an organization affects the set of quality techniques it uses. This finding also implies that the pluralist view of organizational culture not only holds for quality management practices (cf. Prajogo and McDermott, 2005; Zu *et al.*, 2010), but also extends to the level of quality techniques. One caveat applies though, namely, that a firm's use of quality techniques that fit its culture does not imply that these techniques affect performance. The findings related to *RQ2* address this issue.

5.2 RQ2: the associations between organizational culture, quality techniques and performance

For all combinations of cultural profiles and quality technique groups, the quality techniques contribute to performance improvement, except for the rational culture. These results go against Ahire *et al.* (1995), Samson and Terziovski (1999) and Naor *et al.* (2008) who suggest that "hard" quality practices are not associated with performance, but confirm the results of Handfield *et al.* (1999). Furthermore, most cultural profiles are positively associated with performance. The effects are strongest for the rational and group cultures. This result supports the findings of Prajogo and McDermott (2011) who also report a positive relationship between these two cultures and performance.

The developmental culture contributes indirectly to operational performance, irrespective of the quality techniques considered. This effect is stronger through CI quality techniques (0.36) than through GS, measurement (MS) and FPC – 0.29, 0.19 and 0.29, respectively. However, this culture has only direct effects on operational performance when combined with the MS and FPC quality technique groups (0.34 and 0.24, respectively). The total performance effect of the developmental culture is stronger for the MS and FPC techniques than for the GS and CI techniques (0.53, 0.53, 0.29 and 0.36, respectively). However, the indirect effect of MS techniques (0.19 = 36 percent) is much lower than that of the FPC group (0.29 = 55 percent), while the GS and CI groups fully mediate the culture-performance relationship. This result can be explained by the developmental culture's orientation toward flexibility and adaptation to the external environment, innovation and creativity, entrepreneurship and leadership, that is, willing to take risks (Denison and Spreitzer, 1991; Prajogo and McDermott, 2005, 2011; Cameron and Quinn, 2006; Zu *et al.*, 2010), characteristics not directly related to operational performance. So when this culture is matched with quality techniques that are strongly related to its characteristics – i.e. GS and CI, its performance effects come exclusively through these groups.

The group culture has a direct effect on operational performance for all quality technique groups. The indirect effect of GS techniques is insignificant – the total performance effect (0.39) is entirely due to the direct effect. For the CI, MS and FPC techniques, the total effects on performance are nearly equal – 0.57, 0.58, 0.57, respectively. The CI techniques contribute 54 percent (0.31) to the total performance effect, the FPC techniques 47 percent (0.27) and the MS group only 28 percent (0.16). The strong, weak and insignificant contributions of CI, MS and GS, respectively, to the total performance effect reflect the nature of the group culture, which is flexibility oriented, focussed on the internal organization, and characterized by teamwork, participation and belonging, empowerment and trust, concern with human relations, participative leadership and development of human potential and member commitment (Denison and Spreitzer, 1991; Prajogo and McDermott, 2005, 2011; Cameron and Quinn, 2006; Zu *et al.*, 2010). These characteristics are much more consistent with the people, participation and involvement-oriented CI techniques than with the GS and MS techniques. It is not clear why the mediating effect of the FPC techniques is so (relatively) strong.

The hierarchical culture has a direct and indirect effect on operational performance when matched with GS, CI and MS techniques. These three groups contribute 38 percent (0.21), 54 percent (0.30) and 30 percent (0.17), respectively, to the total performance effects of 0.55, 0.56 and 0.56. With its control and internally oriented focus, this culture emphasizes efficiency and predictable outcomes, stability, order and uniformity. These characteristics, which are supported by formalization in the form of rules and regulations, and centralized, technically oriented "leadership" (Denison and

Spreitzer, 1991; Prajogo and McDermott, 2005, 2011; Cameron and Quinn, 2006; Zu *et al.*, 2010), are consistent with the function of the MS and, to a certain extent, the GS techniques. The relatively strong contribution of the CI techniques is surprising, as these techniques are more people, participation and involvement than control oriented. The model measuring the FPC techniques shows full mediation. Considering the nature of this cultural profile, it is surprising that the direct performance effect of the hierarchical culture is insignificant. In contrast, the observation that FPC techniques contribute strongest of all technique groups makes logical sense.

Each of the four models measuring the role of quality techniques in the rational culture shows only direct cultural effects on performance; all indirect effects of culture and direct effects of quality techniques are small and insignificant. Focussed on the external environment, control oriented and characterized by task focus, achievement, clarity, competition, directive and goal oriented leadership, and efficiency and productivity (Denison and Spreitzer, 1991; Prajogo and McDermott, 2005, 2011; Cameron and Quinn, 2006; Zu *et al.*, 2010), this culture has the strongest relationship of all cultural profiles with all quality technique groups (see Figure 3). Apparently, firms with a rational culture feel strongly that they need to use quality techniques to further systematize or standardize their already quite effective *modus operandi*.

5.3 The overall picture

This study supports the pluralist view (e.g. Prajogo and McDermott, 2005; Zu *et al.*, 2010) at the level of quality techniques. That is, there is a "several-to-many" relationship between organizational culture and the *use* of quality techniques (Figure 3). The rational culture is positively associated with the use of all the four quality technique groups, the group and hierarchical cultures with three and the development culture with two of the groups. The strength of the 13 significant relationships various from −0.12 to 0.88; in three cases the association between culture and techniques is insignificant.

While firms can (and do) use many different quality techniques nearly irrespective of their culture, what are the performance effects of these techniques? As shown in Table V, firms with a developmental culture can use MS and FPC effectively, while the GS and CI techniques fully mediate the relationship between this culture and performance. In firms characterized by a group culture, the matches of this culture with CI, MS and FPC techniques are performance effective; the GS techniques do not add to the performance effects of this culture. In firms with a largely hierarchical culture, GS, CI and MS partially mediate the culture – performance relationship; when this culture is combined with the FCP group, these techniques explain the total performance effect. Finally, in firms with a rational culture, it is culture that explains performance; none of the quality techniques – performance relationships is significant.

Thus, while some studies ascertain that social elements of quality management can improve performance even without the technical elements (e.g. Samson and Terziovski, 1999; Naor *et al.*, 2008), this study shows that techniques do contribute to performance improvement if they are supported by appropriate cultural characteristics. This confirms studies claiming that the integration between technical and social elements is essential to improve performance (e.g. Sousa and Voss, 2002; Rahman and Bullock, 2005; Calvo-Mora *et al.*, 2014b), and that they do not necessarily act effectively if they are implemented separately (Calvo-Mora *et al.*, 2014a). The exception is the rational culture. Apparently, the characteristics of this culture, i.e. its dominant orientation, core values, leadership style and performance priorities (Denison and Spreitzer, 1991; Cameron and Quinn, 2006), do not enhance the effectiveness of quality techniques.

6. Conclusion

6.1 Theoretical contribution

This paper extends previous studies of the relationship between culture and quality management by focussing on quality techniques and considering how the interplay between culture and quality techniques affects performance.

The study produced two important contributions. First, it confirms the pluralist view at the level of quality techniques: firms do not appear to be "religious" in terms of their adoption of quality techniques. This point is emphasized in Figure 3, which shows a "several-to-many" relationship between the four cultures and the four quality technique groups. Second, the findings show that, in order to obtain the best results from the use of those techniques, it is fundamental that they are supported by appropriate cultural characteristics. For firms with a developmental or a group culture, it may be much more difficult to benefit from control-related techniques such as MS and FPC than from techniques that are people and development oriented, such as CI and GS. Firms with a hierarchical culture benefit most from the use of FCP techniques. Finally, in firms with a rational culture, the use of quality techniques may not do any harm, but it is the nature of such firms that determines their performance rather than the quality techniques they use.

6.2 Managerial implications

The findings have important implications for managers. First, managers do not need to be overly selective concerning the adoption of quality management techniques. Second, though, the performance effects of culture and quality techniques vary. The performance of firms with a developmental culture is greatly enhanced by the use of quality techniques. For firms with a group or hierarchical culture, the add-on effects of quality techniques are somewhat weaker or even insignificant. In firms with a rational culture, the contribution of quality techniques is small and insignificant. These findings imply that firms need to be actively aware of their cultural characteristics to achieve the best results from the use of quality techniques.

6.3 Further research

The research presented in this paper suggests several directions for further research. First, some of the findings could not be explained adequately. Further research is needed to develop insight into, among others, the widespread use but insignificant performance effects of the quality techniques in the rational culture, the use of FPC techniques by firms with a group culture, and the performance effects of the CI techniques in firms with a hierarchical culture.

The study also has certain limitations, each of which suggests a need for further research. First, the data were gathered via an e-mail survey questionnaire, which was based as much as possible on existing scales and analyzed using an increasingly common technique, SEM, in order to reduce the likelihood to produce findings that are different "just" because of differences in operationalization and methodology. Still, the usual limitations associated with this research approach apply, including a lack of control over who actually completes the survey. Future research should use different methodologies, including interviews, field studies or longitudinal case studies to develop a deeper understanding of the mechanisms behind the statistical relationships reported in this paper. Second, firms function in different contexts. It is important to explore if the performance effects reported here would be different if control variables such as strategy, industry type and firm size are added and the sample is extended beyond Brazil and Denmark.

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Appendix. Measurement scales

Most of the items used in these scales were adapted from Ahire *et al.* (1996), Baird *et al.* (2011), Flynn *et al.* (1994), Kaynak (2003), Naor *et al.* (2008), Prajogo and McDermott (2011), Samson and Terziovski (1999), Wu *et al.* (2011) and Zu *et al.* (2010). The item marked with the symbol (*) was dropped as a result of reliability test.

Organizational culture

For the following statements please indicate the option that matches your view most closely. (1 – Strongly disagree; 3 – Neither agree nor disagree; 5 – Strongly agree)

Hierarchical culture

- Formalized procedures generally govern what people do.
- We emphasize efficiency and control to reach predictable performance results.
- Reliable delivery, smooth scheduling and low-cost production are the main focus.
- Our management style prioritizes conformity, predictability and stability.
- Even small matters have to be referred to someone higher up for a final answer (*).

Group culture

- The development of human resources and concern about employee are highly valued.
- Our employees are encouraged to work as a team, exchange opinions, experiences, and ideas.
- Employees can openly discuss their opinions and ideas with someone higher up.
- Employees are encouraged to take decisions.
- Our management style is characterized by teamwork, consensus and participation.

Rational culture

- Success defined on the basis of winning and leading in the marketplace.
- Our reward system encourages reaching plant goals.
- We are results oriented, people are very competitive and achievement oriented.
- Objectives and aims are clearly defined.
- Our management style is characterized by hard driving competitiveness, high demands and individual achievement.

Developmental culture

- We emphasize prospecting for opportunities and creating new challenges.
- We make an effort to anticipate the potential aspects of new manufacturing practices and technologies.
- We are a very dynamic entrepreneurial place, which leads people to taking risks.
- Our management style is characterized by individual risk-taking, innovation, freedom, and uniqueness.
- We define success on the basis of innovation and having newest products.

Quality techniques

For the following statements please indicate the option that matches your view most closely. (1 – Strongly disagree; 3 – Neither agree nor disagree; 5 – Strongly agree)

Goal setting

- We use methods to identify customers' needs and consider them in our product development.

- We turn customers´ needs and expectations into products' technical features.
- We work in team with members from a variety of areas to identify customers' needs, and consider them in the product development.
- We identify best practices among our different areas, and try to spread them to the whole organization.
- Our employees are encouraged to exchange experiences across areas.
- Best practices have helped improve our products/processes.

Continuous improvement

- Our employees often participate in problem solving, and root cause analysis sessions.
- During problem solving sessions, we make an effort to obtain all team members' opinions and ideas before making a decision.
- Bringing a variety of perspectives to help solve problems leads to better solutions.
- Our employees are encouraged to think about quality improvements in their daily activities.
- Most employees' suggestions turn into improvement initiatives.
- We have focussed and structured actions to reach improvements in a defined period of time.
- We have a cross-functional team working to reach improvement aims in a defined period of time.
- We often use structured methods (i.e. PDCA, DMAIC, etc.) for continuous improvement.
- Most employees in our plant are trained to use quality tools (i.e. Pareto, Cause and Effect Diagram, Histogram).
- We make extensive use of techniques to identify and prioritize problems.
- We are concerned about keeping areas organized with an appropriate place for each thing.
- Our employees keep their work environment clean and organized.

Measurement

- Quality (i.e. scrap and rework) data are readily available to employees.
- Charts showing schedule compliance are displayed on the shop floor.
- Information on productivity is readily available to employees.
- We set strategic goals for quality improvement and control these goals using performance indicators.
- We use quality indicators (i.e. scrap rates, rework rates, quality cost) to measure quality performance.
- We use quality performance indicators to evaluate improvement in organizational performance.

Failure prevention/control

- We use methods to identify failures, possible causes, and means to detect these failures in our products/processes.
- We implement action plans based on our failure and causes analysis to improve products/processes.

- We record historical failures data and action plans to solve these failures.
- We make extensive use of statistical techniques to analyze variance in process.
- Statistical quality control has helped to quality improvements.
- Line workers are well trained in statistical process control.
- We include preventive maintenance activities in production planning.
- We emphasize good maintenance as a strategy for achieving quality and schedule compliance.
- Our maintenance department focusses on assisting machine operators perform their own preventive maintenance.
- Our processes are designed to be mistake proof to minimize the chances of errors.
- Most equipment has devices to indicate the occurrence of errors in production processes.

Operational performance

Please assess the performance level of your organization for each item listed below:

- Customer satisfaction: (1) sometimes meets expectations […] (5) exceeds expectations.
- Productivity is: (1) consistently decreasing […] (5) consistently increasing.
- The unit cost of manufacturing is: (1) consistently increasing […] (5) consistently decreasing.
- Lead-time is: (1) consistently increasing […] (5) consistently decreasing.
- The number of customers´ complaints is: (1) consistently increasing […] (5) consistently decreasing.
- Scrap, rework and defects are: (1) consistently increasing […] (5) consistently decreasing.

About the authors

Lillian Do Nascimento Gambi is an Assistant Professor at the Institute of Science and Technology at the Federal University of Viçosa, Brazil. She holds a BSc in Industrial Pharmacy and both an MSc and PhD in Industrial Engineering from the School of Engineering of São Carlos, University of Sao Paulo. She has professional experience in process and people management, working also with implementation of quality systems in manufacturing companies. Her current research interests are on quality, performance management and innovation. Assistant Professor Lillian Do Nascimento Gambi is the corresponding author and can be contacted at: lillian.gambi@ufv.br

Harry Boer is a Professor of Strategy and Organization at the Center for Industrial Production at the Aalborg University. He holds a BSc in Applied Mathematics and an MSc and PhD both in Management Engineering. He has (co-)authored numerous articles and several books on subjects such as Organization Theory, Flexible Automation, Manufacturing Strategy and Continuous Improvement. His current research interest concerns the organizational aspects of continuous innovation – studied as the effective integration of day-to-day operations, incremental improvement and radical innovation.

Mateus Cecilio Gerolamo is an Assistant Professor at the School of Engineering of São Carlos, University of Sao Paulo. He holds a PhD in Industrial Engineering by University of Sao Paulo and a Post-Doctoral Research on Sustainable Manufacturing by the Technical University of Berlin. He has experience on quality management, supply chain management and change management. His present teaching and research interests are on the subjects of quality management, industrial clusters and organizational culture and leadership. He is Certified in Production and Inventory Management (CPIM).

Frances Jørgensen is an Associate Professor at the School of Business and Social Sciences, Aarhus University. She has research expertise in the area of organizational behavior and HRM, and in particular the role of HRM in supporting employee-driven change, innovative work behaviors and innovation performance. She has numerous publications in internationally recognized scientific journals in the fields, currently serves on the editorial team of creativity and innovation management, has been editor for special issues focussing on innovation for creativity and innovation management and *International Journal of Technology Management* and was organizing committee chair for the 11th International Continuous Innovation Network (CINet) Conference in Aarhus, Denmark. She is an active Member of several professional organizations, including the Academy of Management, Society of Human Resource Management (SHRM) and CINet.

Luiz Cesar Ribeiro Carpinetti is a Professor of Quality and Performance Management at the School of Engineering of Sao Carlos, University of Sao Paulo, Brazil. He holds a BSc in Mechanical Engineering by the University of São Paulo (Brazil), an MSc in Metrology and Quality Assurance by the Cranfield Institute of Technology (UK) and a PhD in Engineering by the University of Warwick (UK). He has (co-)authored numerous articles and several books on the subjects of quality, performance measurement and continuous Improvement. His present research interest includes quality and performance management of suppliers in supply networks.