Process Control and Quality Performance: The role of shop-floor leadership practices

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Abstract

Human Resource Management (HRM) issues are a crucial factor in the effective implementation of tools and practices in the field of Quality Management (QM). Our study addresses this issue by considering the existence of complementarities between Process Control (PC) and two shop-floor leadership practices (i.e., Shop-Floor Contact and Supervisory Interaction Facilitation), directed to promote contact and interaction between middle managers and supervisors with blue collar workers to explain quality performance, which is measured by Quality of Conformance (QC) and Customer Satisfaction (CS). The data used in this study were gathered from 317 manufacturing plants, with more than 100 workers, operating in 10 countries all over the world. Our results confirm the positive effects that PC practices have on both QC and CS. In addition, we observed that leadership practices moderate the relationship between PC and quality performance measures. Specifically, it seems that the Shop-Floor Contact (SFC) interacts with PC to improve CS; whereas, Supervisory Interaction Facilitation (SIF) can be an aid for PC to increase QC.

Keywords: Process Control; Shop-floor contact; Supervisory Interaction Facilitation; Quality Performance

1. Introduction

The positive association between the adoption of Quality Management (QM) practices and the enhancement of both manufacturing and quality performance have been largely documented in the operations management (OM) literature (Nair, 2006). However, it has been stated that many organisations fail to achieve QM success, as a result of problems in the organisational implementation of these practices (Fotopoulos, Psomas, & Vouzas, 2010). In the background, there is some lack of knowledge about which factors are determinant of quality performance; therefore, the present status of research cannot provide clear guidance to managers on how to implement QM practices (Ebrahimi & Sadeghi, 2013). Accordingly, some researchers propose to re-examine the link between QM practices and QM performance, paying more attention to internal and external contingency factors, or even considering the role of moderating factors that influence each specific relationship between various QM practices and quality performance (Dubey & Gunasekaran, 2015; Wayhan & Balderson, 2007; Zhang, Linderman, & Schroeder, 2012).

The principal QM focus remains on the control of processes and assurance practices (Prajogo & Sohal, 2003; Zeng, Phan, & Matsui, 2015). These practices include the monitoring of activities and the designing of fool-proof processes to ensure that customer requirements are met (Mokhtar & Yusof, 2010). Process control (PC) practices are in the core of excellence and continuous improvement (Juran & Gryna, 1993), and they are usually considered as *'hard'* QM practices (Rahman & Bullock, 2005). However, more recently, researchers highlighted that the faltering implementation of QM systems can be explained by deficiencies in *"soft"* QM practices, related with human factors, such as training or leadership. Soft and hard QM practices interact to explain effective implementation and performance (Dubey & Gunasekaran, 2015; Fotopoulus & Psomas, 2009); however, there is a call for more empirical evidence on the moderating impacts of internal organisational factors and different context (Khan & Naeem, 2016). Many QM ‘gurus’, theoreticians and empirical studies have stressed the importance of leadership for the success in the implementation of QM practices; however, the role of leadership in QM has not been fully explored to date (Laohavichien, Fredendall, & Cantrell, 2011).

This paper aims to contribute to this field of research, by analysing how the adoption of PC practices impacts quality performance—i.e., Quality of Conformance (QC) and Customer Satisfaction (CS)—and considering the moderating role of leadership practices that promote the support, facilitation and shop-floor contact of supervisors and middle managers with operators in manufacturing plants. Hence, this paper recognises the role of people within the organisation and the importance of close relationships between managers, supervisors and workers aimed to achieve an effective flow of information and dialogue from top to bottom and bottom to top (Ahn & Matsui, 2011). This, in turn, contributes to a greater worker involvement and, therefore, in the enhancement of quality performance (Mellat-Parast, Adams, & Jones, 2007).

In sum, our research question could be formulated as: What role do leadership styles play in the contribution of PC practices to enhance quality performance? Following the Socio-Technical-System (STS) perspective, which recognises the systematic interactions between technical proficiency and technologies, the involvement of the workforce for the effective implementation of QM practices (Zu, 2009) and the empirical-related evidence, we argue how PC interact with leadership practices to explain quality performance. Empirically, the proposed hypotheses are tested using a sample of 317 manufacturing plants, with more than 100 workers, operating in 10 countries all over the world from the High Performance Manufacturing (HPM) project.

The contributions of this paper are threefold. First, we developed a theoretical reasoning on how workshop leadership practices, adopted by both middle and line managers, can reinforce the effects of PC practices on quality performance. In doing so, we help disentangle the black box between human resource management (HRM) practices and firm performance. Second, we present new evidence on the interaction between hard and soft practices to achieve high performance, using a multiple respondent survey that is integrated with medium-to-large-sized plants located in different contexts. Third, we focus on the role of line managers and their ability to lead their subordinates through facilitation, in addition to involvement practices that can reinforce the effects of the implementation of quality practices and systems.

The paper is organised as follows. Section 2 develops theoretical reasoning, through an overview of the related literature, and proposes two research hypotheses. Next, Section 3 explains the empirical components of the paper, including a description of the survey instrument and data collection methods, the statistical treatment of the measures and, finally, four regression models to test our hypotheses. Section 4 includes the estimation results. In Section 5, the estimation results are discussed. Finally, in Section 6, conclusions and implications are drawn from the research findings, and some limitations are pointed out.

2. Theoretical framework and hypotheses

The STS theory considers an organisation as an open system, where two interacting subsystems coexist: a technical subsystem and a social subsystem. The technical subsystem is composed of tools, techniques, devices, methods, procedures and knowledge, which are used by organisational members to acquire inputs, transform inputs into outputs and provide outputs or services to clients or customers. The social subsystem, on the other hand, consists of the people who work in the organisation and their social interactions with one another (Pasmore, 1988). The STS theory, thus, recognises the importance of social forces in work organisations, frequently creating a shift from individual to group methods for performing jobs (Manz & Stewart, 1997).

The STS theory is useful for explaining the implementation of QM practices, since it implies a systematic interaction between technical proficiency, technology and the involvement of the workforce (Mohanty, 1997; Zu, 2009). For instance, Kull, Narasimhan, and Schroeder (2012) use a multilevel model of QM and develop time-oriented hypotheses with a STS perspective to examine the role of cooperative values. Ho, Duffy, and Shih (2001) suggest that the core QM practices that involve the extensive use of procedures, tools and techniques in solving quality problems and improving product and service quality, to satisfy customers' needs and expectations, may be categorised as the technical subsystem. Meanwhile, the infrastructure QM practices (i.e., those that try to establish a learning and cooperative environment through organisational change and development efforts to ensure top management support, employee involvement, and customer and supplier involvement) can be described as the social subsystem.

2.1. *Process Control and Quality Performance*

The relationship between QM practices and quality performance has been largely addressed by researchers in the field of OM (Clegg, Gholami, & Omurgonulsen, 2013; Dow, Samson, & Ford, 1999; Forza & Filippini, 1998; Kaynak, 2003; Merino-díaz De Cerio, 2003; Parvadavardini, Vivek, & Devadasan, 2016; Prajogo & Sohal, 2003; Samson & Terziovskib, 1999). In spite of some exceptions (Dow et al., 1999; Samson & Terziovskib, 1999), these studies indicate that QM practices have a positive and significant impact on quality performance. Nair (2006) summarise these findings in a meta-analysis study, which reveals a positive correlation between several QM practices and performance measures.

PC is in the core of QM (Kaynak, 2003). These include the use of Statistical Process Control (SPC) practices and other ways to control the production processes, such as the designing of 'full-proof' processes. PC is, by far, one of the most popular organisational interventions in the field of QM (Lascelles & Dale, 1988; Modarress & Ansari, 1989). The fact that PC implementation improves quality performance is a common conviction among quality practitioners. According to Rungtusanatham (1999), PC implementation can have a positive impact on product quality through improved process quality. By monitoring, controlling and minimising the variation that affects the transformation process, the PC practices makes the transformation process more capable, stable and reliable (Anderson, Dooley, & Rungstusanatham, 1994). Moreover, PC reassigns responsibility and control of the transformation process away from specialists towards process operators who can, therefore, respond faster in detecting, correcting and preventing causes of variation.

This better-quality process leads to a higher quality product, understood as conformance to requirements (Crosby, 1979). From this view, a highly conforming product has measurable dimensions whose numerical values approximate their target nominal values (low variance), requiring, in turn, that the manufacturing process be statistically stable and capable (Deming, 1982; Zeng, Phan, & Matsui, 2015). Normally, managers and engineers have emphasised the benefits that PC interventions provide to the technical side of the production process (i.e., better quality or operational performance), but it is interesting to highlight the impact of these practices on STS aspects—creating more enriched jobs for process operators and enhancing work motivation and job satisfaction (Rungtusanatham, 1999; 2001).

Empirically, the positive relationship between PC practices and quality performance has been supported by many studies (Adam, 1994; Ahire & O’Shaughnessy, 1998; Cua, McKone, & Schroeder, 2001; Forza & Filippini, 1998; Kaynak, 2003; Laohavichien et al., 2011; Lim, Antony, Arshed, & Albliwi, 2017; Zeng et al., 2015).

2.2. *Process Control (PC) and Quality Performance: The moderating role of leaders´ support and contact*

Leadership is a key element for QM success. It is one of the main criteria of the Malcolm Baldrige, EFQM and other models of excellence in the field of QM. Pioneers of the quality movement, such as W. Edwards Deming and Joseph Juran, have always insisted on the importance of leadership for moving forward in implementing quality models and management systems in companies (Crosby, 1979; Deming, 1982). According to Deming (1982, pp 248), 'The aim of leadership should be to improve the performance of man and machine … to increase output and simultaneously to bring pride of workmanship to people … to help people to do a better job with less effort'.

Leadership is a core topic in organisational theory. There are numerous focuses on this subject, which bears witness to its complexity. For example, Robbins and Judge (2013) distinguish between trait theories, behavioural theories, contingency theories and Leader-Member Exchange theories. One modern theory on leadership is the Multifactor Leadership Theory (Bass & Avolio, 2000), which proposes three distinct leadership styles: (1) transformational leadership (TFL), which is based on charisma and inspiration; (2) transactional leadership, which is based on rewards and punishments; and (3) laissez-faire leadership, which is backed on a lack of leadership. TFL has been proposed and supported as the most successful among the three leadership styles (Bass, 1990; Bass & Avolio, 2000; Bass & Riggio, 2006). Transformational leaders inspire their followers to look beyond their own personal interests for the good of the organisation. They pay attention to their concerns and personal development needs, change their attitude to issues by helping them to see old problems in new ways and they encourage them to go that extra mile for the group to achieve its goals (Robbins & Judge, 2013).

Dean and Bowen (1994), comparing Total Quality Management (TQM) and Management theory, stated that leadership is widely shared by both fields. Leadership emphasizes communication and reinforcement of the values of the organization, and the articulation and implementation of its vision. Specifically in TQM, this entails aligning organisational members' values with quality values of customer focus, continuous improvement and teamwork. Waldman (1994) considers that the institution of vision and TQM value-oriented leadership practices are key factors, and they are also the models that best adapts to the ideas on leadership proposed by TQM.

It is important to note that leadership research has mostly focused on the impact of leader behaviours on the follower's individual performance and satisfaction, rather than organisational performance. Broadly speaking, empirical evidence indicates that transformational leadership is linked to lower rates of staff rotation, greater productivity, less stress and greater employee satisfaction (Hetland, Sandal, & Johnsen, 2007; Judge & Piccolo, 2004; Yammarino, Spangler, & Bass, 1993). While the effects of leader behaviours on employee performance are interesting, the most important effects appear to be on superior organisational performance. With this regard, transformational leadership has a positive effect on organisational performance, individually (Birasnav, 2014; Elenkov, 2002; Masa´deh, Obeidat, & Tarhini, 2016), mediated by organisational justice, organisational trust and employee reactions (Katou, 2015) or through organisational learning and innovation (García-Morales, Jiménez-Barrionuevo, & Gutiérrez-Gutiérrez, 2012).

However, empirical literature that analyse the effects of shop-floor leadership practices on organisational performance is scant. In addition, to our knowledge, there is no evidence analysing the interaction of these practices with QM tools, such as PC on quality performance. In this paper, we will analyse two shop-floor leadership practices (i.e., Shop-Floor Contact (SFC) and Supervisory Interaction Facilitation (SIF)), which capture how line managers and supervisors interact with their subordinates in the daily work.

SFC measures the extent to which managers and engineers cooperate with line workers, and help and enable them to solve production problems. SFC gives opportunities for 'providing individualised support', the dimension of Podsakoff, MacKenzie, Moorman, and Fetter's (1990) scale, which measures the behaviours of the leader that demonstrates the leader's concern for individual subordinates. Also, greater contact with shop-floor employees can serve to trigger intellectual stimulation and to promote inspirational motivation.

Employees must be involved in the process of change and this involvement is affected by creating a work environment that encourages and facilitates open communication (Kaynak, 2003). This trust-based work environment can be generated by a closer relationship between line managers, engineers and operators, leading to improved quality performance. Related empirical evidence is practically non-existent. The research of Ahn and Matsui (2011) found significant and positive correlations between SFC and several measures of operational performance, including QC. However, the indirect effect of SFC, through the strengthening of other management practices, has not been previously analysed. In this sense, it is reasonable to think that higher levels of SFC may produce positive synergies in the relationship between PC and quality performance. Leadership, at the front-line level, can compensate for a certain amount of indifference or scepticism in blue collar workers (Harris & Yit, 1994), which may reinforce the effects of PC practices on quality performance. Thus, we propose the following hypothesis:

H1: Shop-Floor Contact (SFC) moderates the impact of Process Control (PC) on quality performance.

The second practice we analyse in this study, SIF, measures the degree to which supervisors encourage workers to work in a team and exchange opinions and ideas for joint problem solving. Through this practice, supervisors can 'foster the acceptance of group goals', another dimension of Podsakoff et al. (1990) scale, which measures the leadership behaviours that encourage subordinates to cooperate and sacrifice some of their own goals to achieve the group goals (i.e., it encourages teamwork). Furthermore, this form of group work can promote the intellectual stimulation that characterises transformational leadership.

Many studies find a direct relationship between involvement practices and performance (Cappelli & Neumark, 2001; MacDuffie, 1995; Shah & Ward, 2003; Wood, Veldhoven, Croon, & de Menezes, 2012). Elg, Olsson, and Dahlgaard (2008) find that teamwork, an involvement practice, is a major factor in implementing PC successfully. However, no study analyses the indirect effect of facilitation practices on organisational performance. Thus, it is reasonable to think that a leadership style that encourages employees to become involved in work teams, contribute and share ideas (e.g., SIF) can motivate workers to do their work better and be involved in the effective implementation of PC. The implementation of PC requires information, obtained at the work station, to be analysed and treated, so it can be done more effectively, and better results can be obtained in the presence of SIF. For this reason, we consider the following hypothesis:

H2: Supervisory Interaction Facilitation (SIF) moderates the impact of Process Control (PC) on quality performance.

3. Research methodology

3.1. *Description of data and sample*

The data used for the empirical analysis was collected as part of the third round of the HPM research project. The database contains data from 317 manufacturing plants, located in the USA, Germany, Sweden, Finland, Austria, Japan, Spain, Italy, China and South Korea. The average size of each plant is 867 workers. In terms of selection, the manufacturing plants were selected, based on the following three instructions: (1) approximately half of the plants should be ‘high performers’; (2) the other half of the plants should be ‘standard performers’; and (3) each plant should employ more than 100 employees. To select those plants included in the first group, researchers in each country use lists of companies that have been acknowledged for their excellence or those that have a reputation of excellence in their sector. The standard or traditional plants were randomly selected from a master list of manufacturing plants in each country (i.e., using Dun's Industrial Guide, JETRO database, etc.). This stratified sampling design ensures a sufficient number of high performing plants in the sample along with more representative standard plants. Up to 60% of the plants that were contacted in all countries, submitted data for the study.Table 1 provides a description of the sample.

Table 1. Number of Plants by Industry Sector and Country.

Country	**Electronics**	**Machinery**	**Automotive components**	**Total**
Austria	10	7	4	21
China	21	16	14	51
Finland	14	6	10	30
Germany	9	13	19	41
Italy	10	10	7	27
Japan	10	12	13	35
South Korea	10	10	11	31
Spain	9	9	10	28
Sweden	7	10	7	24
United States	9	11	9	29
TOTAL	109	104	104	317

The unit of analysis is the manufacturing plant. The information—provided by plants that integrated the HPM project—was collected, using 12 different questionnaires that were directed at different plant functions (e.g., plant management, supply chain management, QM, human resources management, plant supervision, etc.). In addition, they were asked to complete two questionnaires plants of each type in each function, requiring that at least one was completed. Many of the scales were included in different questionnaires, which allows the researcher to capture answers from employees of different functions and positions in the hierarchical structure (e.g., managers, supervisors and direct labour). This helped to reduce potential common-method variance (CMV) bias (Podsakoff, MacKenzie, & Podsakoff, 2012). Table 2 shows different items.

In case of more than one interviewees response, different scores were averaged to obtain a single value for each item for each plant. Although an average value may reduce the individual information for each respondent, it allows a more accurate and less-distorted view of the question under study in each plant (Podsakoff et al., 2003). In addition, according to Hair et al. (2009) the use of additive scales has two advantages. Firstly, they provide a means of overcoming, to some extent, the measurement error. Secondly, they are capable of representing multiple aspects of a concept within a single measure.

3.2. *Measures*

We use five variables—four of which are scales or latent constructs—for testing the hypotheses in this study. Three of these latent constructs are independent variables: (1) PC; (2) SFC; and (3) SIF. The other latent construct is one of two dependent variables (i.e., the quality performance measures): Customer Satisfaction (see Table 2).

The literature proposes several performance types that can be obtained as a result of the implementation of QM practices that extend well beyond quality dimensions and concern the improvement of the whole organisation (Forza & Filippini, 1998). In this study, the field of investigation has been purposely limited to those elements of quality performance measures that are close related to PC: Customer Satisfaction (CS) and Quality of Conformance (QC). The choice of these two quality performance measures responds to the fact that both approaches support QM principles, quality as product conformity with specifications and quality as CS. These measures have been widely used in related empirical research (Choi & Eboch, 1998; Forza & Filippini, 1998; Fynes, Voss, & Búrca, 2005; Samson and Terziovskib, 1999; Zhang, Vonderembe & Lim, 2003; Zhao et al., 2013; Bortolotti et al., 2015).

For CS, we asked the managers to evaluate in their company the degree of compliance with the specifications of the product and the level of satisfaction of their customers. The scale is integrated by six items on a 1- 7-point Likert scale[1] (see Table 2) (see Zhang et al., 2003; Zhao et al., 2013).

QC is measured using a 5-point Likert scale, which captures how QC is achieved by an individual plant when it is compared to its competitors. On one end of the spectrum, it takes the value of one (1) if a quality manager perceives the QC of a plant as very low, compared to its competition. On the other end of the spectrum, it takes the value of five (5) if a quality manager perceives the QC of a plant as very high, compared to its competition (Phan, Abdallah & Matsui, 2011; Bortolotti et al., 2015)

Two statistical tests have been carried out to control a potential CMV bias. According to Harman´s test, if CMV exists, a single factor will emerge from a factor analysis of all the survey items. The results show that the one factor explains 36.28% of the variance, which is far from the limit of 50%. The other method to control for CMV is the Common Latent Factor method. In our study, the common variance is 8.8%, which is also far from 50%. Therefore, we conclude that CMV is not likely to be a significant issue in our data set.

Initially, we have conducted an exploratory factor analysis (EFA), using the principal component analysis—with Varimax rotation—to identify the underlying dimensions of the scales used to test their 'unidimensionality'. Items are reflective measures (Podsakoff & Organ, 1986) and, therefore, are treated following the methodology proposed by Nunnally (1978). Thus, the EFA data analysis has the ability to produce descriptive summaries of data matrices that aid in the detection of meaningful patterns among a given set of variables. The loadings of the items, captured in the four latent constructs, meet the minimum required of 0.60 (Judge,

[1] Some studies have analysed any differences that might exist when using Likert scales with different points systems (e.g., a 5-point, 7-point, or 11-point Likert scale) to measure a variable, in terms of reliability and validity. The obtained results indicate that 'in the main' there are no differences (Chang, 1994; McKelvie, 1978).

Hill, Griffiths, Lütkepohl, & Lee, 1982), reflecting high construct validity. Convergent validity has also been assessed using the per cent of total variance explained. The values reported in Table 2, are much higher than 50%, indicating acceptable convergent validity.

The constructs' internal consistency (i.e., reliability) was checked by computing Cronbach alphas. Results indicate that the items used are reliable instruments for measuring the four constructs, since all Cronbach alphas are greater than 0.70. Additionally, confirmatory factor analyses (CFAs), using AMOS, were conducted to validate the measurement instrument, following Ahire and Devaraj (2001). The results of the CFAs can be considered acceptable for the four latent variables. Goodness of Fit index (GFI) exceeds 0.90 for all the constructs (from 0.947 to 0.995), indicating unidimensionality. Reliability is demonstrated by a composite reliability above 0.7 (from 0.728 to 0.889). The Bentler-Bonnet coefficient (NFI) was above the minimum threshold of 0.80 (from 0.875 to 0.996), indicating convergent validity. Finally, the discriminant validity was verified, checking that the per cent of variance extracted from all the latent constructs was higher than the squared correlation estimate between constructs.

Table 2. Statistic Treatment: Validity and Reliability Analysis

	Factor Loadings			
Items	**PC**	**SFC**	**SIF**	**CS**
Processes in our plant are designed to be "foolproof"	.629			
A large percent of the processes on the shop floor are currently under statistical quality control	.892			
We make extensive use of statistical techniques to reduce variance in processes	.898			
We use charts to determine whether our manufacturing processes are under control	.779			
We monitor our processes using statistical process control	.914			
Managers in this plant believe in using a lot of face-to-face contact with shop floor employees.		.765		
Engineers are located near the shop floor, to provide quick assistance when production stops		.759		
Managers are readily available on the shop floor when they are needed		.700		
Manufacturing engineers are often on the shop floor to assist with production problems		.745		
Our supervisors encourage the people who work for them to work as a team			.863	
Our supervisors encourage the people who work for them to exchange opinions and ideas			.868	
Our supervisors frequently hold group meetings where the people who work for them can really discuss things together			.814	
Our supervisors rarely encourage us to get together to solve problems (r)			.655	
Our customers are pleased with the products and services we provide for them.				.878
Our customers seem happy with our responsiveness to their problems				.801
We have a large number of repeat customers				.556
Customer standards are always met by our plant				.815
Our customers have been well satisfied with the quality of our products over the past three years				.870
In general, our plant's level of quality performance over the past three years has been low, relative to industry norms (r)				.672
Reliability (Cronbach´s α)	.882	.719	.788	.853
Variance explained (cumulative %)	68.8	55.1	64.8	59.9

r = reverse-scaled item

Finally, four additive indexes were created for PC, SIF, SFC and CS, calculating the arithmetic average of their respective items (Hair et al., 2009). For QC, the quality manager of the plant was asked to evaluate the competitive position of the plant with respect to its competitors. The use of this measure is more appropriate than using absolute conformance values (e.g., the percentage of defects), as these values are greatly impacted by each plant's own type of production process or industry sector (Venkatraman, 1990). Table 3 presents the descriptive statistics and Pearson correlations between the variables. All variables have mean values in the upper halves of their scales. Also, the data presents significant variability with respect to all five measures used in this study.

Table 3. Descriptive statistics and Pearson Correlations

			Correlations			
Variables	Mean	SD	PC	SFC	SIF	CS
PC	4.72	.89				
SFC	5.46	.61	.27**			
SIF	5.18	.65	.34**	.43**		
CS	5.34	.53	.35**	.38**	.41**	
QC	3.88	.69	.19**	.22**	.20**	.27**

4. ** p≤0.01

5. Results

The method used to test the hypotheses, established in Section 2, is the ordinary least squares multiple regression model (OLSMR). This regression analysis is commonly used to test the moderation relationship (Naor, Goldstein, Linderman, & Schroeder, 2008). The data was checked for basic assumptions of linearity, homoscedasticity and normality. As we are dealing with two quality performance variables (i.e., QC and CS) and two leadership-related variables (i.e., SFC and SIF), four regression models were proposed for analysing moderation effects. Two base models were also added, which relate PC to each of the quality performance measures. The six estimating models are as follows:

(1) $QC_i = \alpha_0 + \alpha_1 PC_i + \alpha_2 SFC_i + \alpha_3 SIF_i + \beta X_i + \varepsilon_i$

(2) $QC_i = \alpha_0 + \alpha_1 PC_i + \alpha_2 SFC_i + \alpha_3 SIF_i + \alpha_4 PC_i{}^* SFC_i + \beta X_i + \varepsilon_i$

(3) $QC_i = \alpha_0 + \alpha_1 PC_i + \alpha_2 SFC_i + \alpha_3 SIF_i + \alpha_4 PC_i{}^* SIF_i + \beta X_i + \varepsilon_i$

(4) $CS_i = \alpha_0 + \alpha_1 PC_i + \alpha_2 SFC_i + \alpha_3 SIF_i + \beta X_i + \varepsilon_i$

(5) $CS_i = \alpha_0 + \alpha_1 PC_i + \alpha_2 SFC_i + \alpha_3 SIF_i + \alpha_4 PC_i{}^* SFC_i + \beta X_i + \varepsilon_i$

(6) $CS_i = \alpha_0 + \alpha_1 PC_i + \alpha_2 SFC_i + \alpha_3 SIF_i + \alpha_4 PC_i{}^* SIF_i + \beta X_i + \varepsilon_i$

where *i* is the company index, QC and CS are the quality performance variables (i.e., quality of conformance and customer satisfaction, respectively) and PC indicates the PC adoption. SFC and SIF (i.e., shop-floor contact and supervisory interaction facilitation) are the two dimensions of transformational leadership. *X* is a control variable vector, and *ε* is unobservable information.

The control variables, firm size (Size) and industry, were considered in the regression models. Size was measured by the natural logarithm, based on the number of plant employees. The industry was incorporated into the regression model by creating dummy variables. The automotive industry was arbitrarily taken as the baseline or comparison group.

Models 1 and 4 are used as baseline models; Models 2 and 5 are used to test *H1*; and Models 3 and 6 are used to test *H2*. The statistical significance of the regression coefficients allows the acceptance or rejection of the proposed hypotheses. To address the problem of multicollinearity, we follow the procedure recommended by Jaccard and Turrisi (2003); namely, using mean-centred data in the independent variables. When the α-coefficient of the interaction term is statistically significant and the coefficient of determination (R squared) increases when this term is introduced into the model, the existence of a moderated effect is demonstrated. The results obtained from estimating the six models are given in Table 4.

Table 4. Ordinary Least Squares Multiple Regression Model. Estimation Results

	Quality Conformance (QC)			Customer Satisfaction (CS)		
	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)
Constant	1.834***	3.305***	3.037***	2.795***	4.585***	4.591***
Size	-0.007	-0.034	-0.001	-0.075***	-0.072***	-0.074***
Electronics	.007	.002	.007	.104	.092	.104
Machinery	.211*	.206*	.192*	.164**	.153**	.160**
PC	.143***	.143***	.139***	.146***	.144***	.145***
SFC	.141*	.146*	.141*	.193***	.201***	.193***
SIF	.111	.104	.086	.215***	.202***	.211***
PC ∗ SFC		.046			.087*	
PC ∗ SIF			.135*			.028
N	251	251	251	268	268	268
F	3.97***	3.45**	3.90***	18.84 ***	16.78***	16.15***
R^2 / adj. R^2	.089/.066	.090/.064	.101/.075	.302/.286	.311/.293	.303/.284

***p≤.01 **p≤.05 *p≤.10

Some interesting evidence can be observed. Firstly, a statistically significant and positive relationship between PC and the two quality performance measures is observed. The R^2 is also observed to be significant in both cases, but higher for CS. However, it is important to note that when an interaction effect is introduced into a model, a complete interpretation of the effects of independent variables on the dependent variables (i.e., CS and QC) must also take into account the coefficients of both the main effect (i.e., PC) and the interaction moderator variables (i.e., SFC and SIF). In this respect, if the sum of the partial effects is positive—individual effect (α1) and interaction effect (α4 * SFC; α4 * SIF)—a synergistic relationship between the variables exists.

In addition, it can be seen that in all models the SFC variable has statistically significant and positive relationships with the quality performance measure variables. However, the SIF variable has a statistically significant and positive impact on CS but not on QC. As for the control variables, it seems that Size has a negative effect on CS; however, its magnitude is small, and machinery firms show higher values than automotive on both quality performance criteria.

In the regression models (i.e., Models 2, 3, 5 and 6), PC, SFC and SIF were introduced, followed by each interaction term entered individually, but were removed before the next one was introduced. The interaction between PC and SFC has a statistically significant and positive impact on CS but not on QC. However, the interaction between PC and SIF has a statistically significant and positive impact on QC but not on CS. The interaction effect of SIF and SFC can be observed in Figures 1 and 2, respectively. Three levels are included for both SIF and SFC: (1) low (i.e., the mean minus the standard deviation); (2) medium (i.e., the mean); and (3) high (i.e., the mean plus the standard deviation).

Thus, with regard to *H1* and *H2*, the synergistic effect between PC, SFC and SIF on quality performance measures can be only partially confirmed.

Figure 1: Two-way interaction effect between PC and SIF. Dependent Variable: Quality of Conformance.

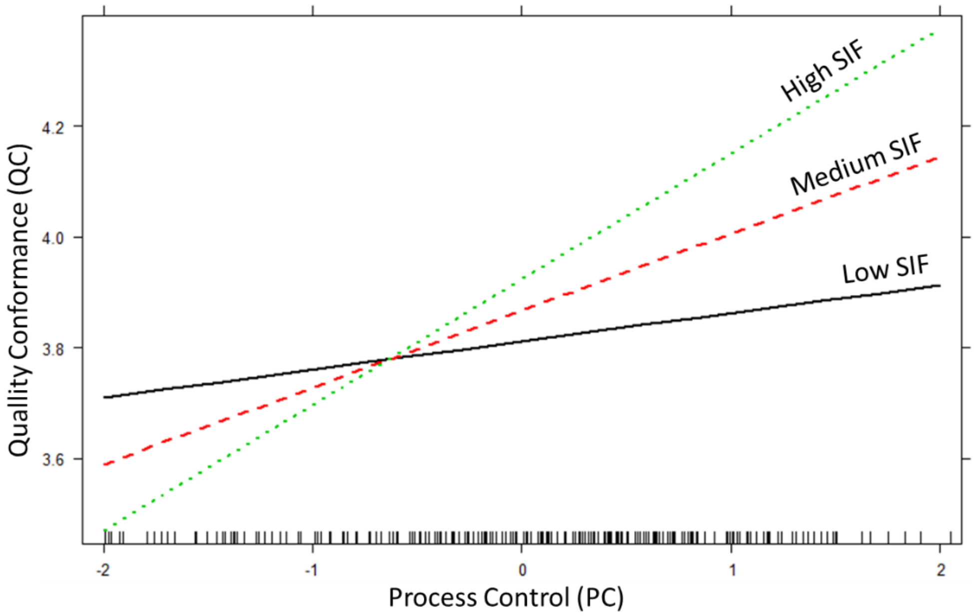
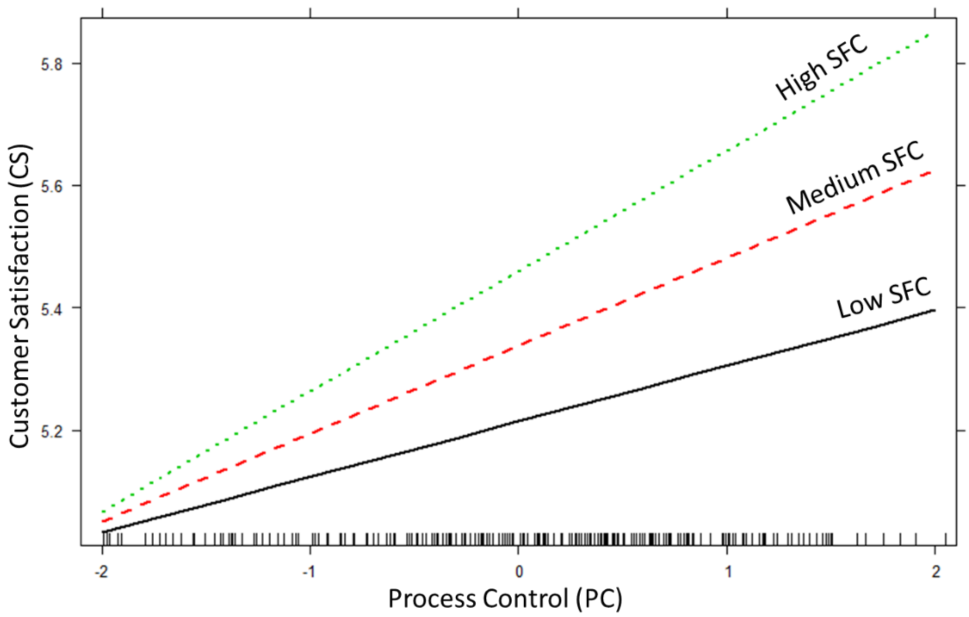


Figure 2: Two-way interaction effect between PC and SIF. Dependent Variable: Customer Satisfaction



6. Discussion

Regarding the direct effect of PC on quality performance, the results corroborate the findings of the majority of the empirical studies that have analysed the adoption of practices in the field of TQM and quality performance. PC instruments are used to determine whether the machinery and the various production processes are under control or not. For instance, statistical PC reduces and controls process variability. The reduction of variability produces several benefits, such as: output uniformity and conformance, a reduction in parts to be reprocessed or rejected, a reduction in waste and, ultimately, CS.

With regard to the effect of workshop leadership practices, Huselid (1995) suggests that the behaviour of employees within firms has important implications for organisational performance. In particular, he suggests that HRM practices can affect individual employee performance and discretionary effort through their influence over employees' skills and motivations. According to our estimation, the individual effect of close contacts and communication between different hierarchical levels in the organisation (i.e., SFC) is positive and has a statistically significant impact on both QC and CS. Managers and engineers are in a very strategic position between line managers and customers. This position facilitates the communication on demand to the shop floor; therefore, the strengthening of contact between all actors contributes to conformity of products and the satisfaction of customers. However, the individual impact of practices that encourage interactions between blue-collar workers (e.g., integrating improvement groups or working teams (i.e., SIF)), was statistically significant for CS. This result highlights that positive externalities of promoting contact and interaction between shop-floor workers positively affect different aspects that are related to the quality of products and processes that determine the satisfaction of customers (e.g., responsibility, response to demands or meting standards of quality over time).

With regard to the interaction effect, we are aligned with the view that the adoption of PC practices demands that the labour force be involved in the process of quality improvement—a crucial factor, previously recognised by all quality theorists. In accordance with such view, we have hypothesised that workshop leadership practices—aimed at increasing trust between managers, supervisors and employees (i.e., SFC) and encouraging teamwork (i.e., SIF)—can positively influence the organisation's objectives and ensure that each objective is achieved.

Estimation results have shown differences in the impact of transformational leadership measures (i.e., SFC and SIF) on quality performance. Our estimation results indicate that PC becomes more powerful for satisfying customer demands when line managers and engineers are closer to employees (see Figure 2). In addition, we observed that when supervisors encourage their workers to form teams and contribute to improvements (i.e., SIF), the impact of PC on QC is also greater (see Figure 1). These findings support the idea, expressed by Forza and Filippini (1998), that 'these instruments are weak when only used by quality control specialists, but they become extremely powerful when the whole staff (and in particular the shop-floor workers) learn how to use them and apply them to their own activities'. Moreover, this result is consistent with the STS theory, which holds that joint optimisation of both socially- and technically-oriented policies or practices is necessary for achieving good results.

7. Conclusions, implications, and limitations

This paper contributes to the current literature on QM, by analysing the moderating role of shop-floor leadership practices that are aimed to promote contact and facilitation between managers, supervisors and shop-floor workers. In addition, this paper analyses the relationship between PC and quality performance measures (i.e., QC and CS).

The results of this study highlight that leadership practices interact with PC practices to explain quality performance. It is remarkable that SFC has a direct and positive effect on QC and CS; whereas, SIF only affects CS directly, but not QC. These results would suggest that promoting the interaction between shop-floor workers (i.e., SIF) do not have a direct effect on QC and needs to be complemented with a more formal procedure.

With regard to moderation effects, it is remarkable that there is evidence of a synergistic effect between SFC and PC to enhance CS. This observation arguably indicates that managers and engineers, who are generally in close contact with customers, really know the whole production process and are able to effectively communicate and convey information to clients; which, in turn, may increase their satisfaction. Typically, blue-collar workers do not perform this role; which, in turn, can be observed in the absence of and interaction effect between SIF and PC to explain CS. On the other hand, for conformance with product specifications (i.e., QC), supervisors' practices promoting teamwork and the exchange of opinions and ideas among workers for joint problem solving (i.e., SIF) reinforces the positive effect of hard practices, such as PC. Nevertheless, promoting contact and interaction between line managers and blue-collar workers (i.e., SFC) does not enhance the effect of PC on QC.

The main findings of this research are relevant to both QM researchers and practitioners. For researchers, the paper highlights the main interaction effects between both hard and soft QM practices that are important to improve the knowledge on the mechanism behind an effective implementation of practices; which, in turn, enhance quality performance. In addition, we have observed that different leadership practices have different fit with the quality performance measures evaluated. For practitioners, the results of this paper, firstly, confirm the beneficial effects of implementing PC practices aimed at obtaining improvements in quality performance, not only for QC but also for CS. More importantly, we observed that the promotion of closer relationships between managers, supervisors and blue-collar workers, help to solve organisational problems and create an environment of trust.

In addition, our evidence shows that practices promoting interaction between blue-collar workers should be complemented with a formal system of quality control to improve quality performance, especially the compliance of product specification. If line managers want to improve quality performance, they should exercise a kind of leadership that goes beyond monitoring and control. Specifically, they should work to strengthen the commitment of its employees driving practices (i.e., SFC or SIF), which can help to generate greater confidence and greater involvement in aligning personal goals with those of the organisation.

Moreover, it would be desirable for companies to establish programs to encourage daily contact of line managers and engineers with plant workers in order to stimulate the interaction between them by introducing, for example, an evaluation of these aspects in surveys of employee satisfaction at the plant. A positive score on these characteristics of transformational leadership in the selection process of line and middle managers would help in this regard.

Finally, of course, this study is not free of limitations. Firstly, the cross-sectional character of the data used in this study limits the explanation of the causal relationship between the QM practice implementation and quality performance. Thus, a well-designed research study, using longitudinal or panel data, can better address the issue of causality. Secondly, the selection process and the small sample size of our research limits the representativeness of the sample on a worldwide basis.

Thirdly, further examination is needed for the transformational leadership style, with the inclusion of other dimensions. As stated by Childe (2009), ‘leadership is a perennial problem for operations managers, which receive attention from time to time’. Therefore, it would be interesting, in future studies, to advance knowledge of the incidence of different leadership practices and its relationship with the external and internal environment to help managers achieve organisational objectives. Moreover, it would be of great interest for the study to be extended to other core QM practices and performance quality measures (e.g., flexibility or innovation performance).

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