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Are quality and innovation management conflicting activities?

Nuria López-Mielgo [a,*], José M. Montes-Peón [b], Camilo J. Vázquez-Ordás [b]

[a] University of Oviedo, Department of Business Administration, Fac. CC. Economicas y Empresariales, Avda. del Cristo s/n, 33071 Oviedo, Spain
[b] University of Oviedo, Fac. CC. Economicas y Empresariales, Avda. del Cristo s/n, 33071 Oviedo, Spain

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ABSTRACT

It is commonplace to assert that hard components of quality management inhibit innovation. In fact, the relationship between these two activities (quality and innovation management) is complex and, as claimed in this paper, bi-directional. Some recent works suggest that innovative companies are used to change management and therefore would find adopting quality management routines less demanding and less expensive than non-innovative companies. This paper builds on this view and proposes that innovation capabilities linked to certain valuable resources (better conditions) favor the implementation of hard components of total quality management. Innovation capabilities are key dynamic capabilities accumulated over time. In order to capture their complexities, they are modeled in a broad manner including both product and process innovations, as well as R&D and high technological level. For verifying the hypotheses, a random-effect probit model is tested on a large multi-industry panel of Spanish firms. Unobservable individual heterogeneity and time effects are controlled with this approach, which means a noteworthy improvement over previous research. The results strongly confirm the positive link between innovation capabilities and quality management. It is also demonstrated that some resources of the firm facilitate standardization and quality control activities. These findings have important managerial implications. On the one hand, developing innovation capabilities will permit companies to be proactive in the adoption of standardized management systems. On the other hand, quality and innovation departments should cooperate in order to ease the standardization of new products and processes.

1. Introduction

Quality and innovation management are increasingly high-profile activities for all kinds of firms and are usually associated with gaining a competitive advantage. Both can be considered as organizational dynamic capabilities based on learning, improvement and change. However, managers frequently emphasize that they find substantial conflicts between quality and innovation activities. Unsurprisingly, these conflicts have caught the attention of academics.

A review of the literature on the relationship between total quality management (TQM) and innovation shows that this relation is complex and depends on the specific elements taken into account in each case (Abrunhosa and Sá, 2008). Furthermore, both activities are multidimensional in nature.

Total quality management consists of a large number of elements or actions that various authors have classified into two large groups, although using different labels (Abrunhosa and Sá, 2008; Prahogo and Sohal, 2004; Moreno-Luzon and Peris, 1998):

(1) Hard components, mechanistic elements or quality assurance (HC). These are practices relating to the control of processes and products to comply with quality standards and satisfy manufacturing specifications.
(2) Soft components, organic elements or total quality management (SC). These are measures that seek to gain the involvement of managers and employees in the quality management: training, learning, and internal cooperation or teamwork. These measures aim to promote the human aspects of the quality system so the firm can adapt to its changing environment and promote continuous improvement.

In turn, innovations can also be classified into two large groups: incremental and radical. Incremental innovations are improvements in the firm's current products and/or processes, while radical innovations are based on more profound changes, often knowledge advances resulting from research and development (R&D) activities. This second type of innovation gives rise to totally new products.

* Corresponding author. Tel.: +34 98 5106208; fax: +34 98 5103708.
E-mail addresses: nlopez@uniovi.es (N. López-Mielgo), jmmontes@uniovi.es (J.M. Montes-Peón), cvordas@uniovi.es (C.J. Vázquez-Ordás).

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Some studies find that firms that implement the SC tend to be more innovative (Prahogo and Sohal, 2001, 2006a, 2006b; Singh and Smith, 2004; Santos-Vijande and Álvarez-González, 2007; Molina et al., 2007; Sá and Abrunhosa, 2007; Abrunhosa and Sá, 2008). More specifically, some papers find that the SC favor incremental innovations (Prahogo and Sohal, 2004; Abrunhosa and Sá, 2008), due to the firm's orientation toward continuous improvement.

In addition, some authors argue that HC inhibit innovation, particularly radical innovation, since the rationality, efficiency and strict control of the tasks that are imposed in the production process drown the creativity required to impose deep changes in the way of doing things (Benner and Tushman, 2002; Prahogo and Sohal, 2004). Radical innovation requires improvisation and less adherence to established routines.

Hence, the literature on the relation between quality management and innovation has shown considerable interest in how the former affects the latter. But the inverse effect (i.e., the question of whether a solid innovation strategy has any type of effect on the implementation of TQM) has not been extensively studied.

A few papers deal with this topic but they treat it only tangentially or they focus on specific industries. On the one hand, Escanciano et al. (2002) present some evidence that indicate that firms with a higher technological level and a more active innovation strategy are more satisfied with the benefits of the HC of TQM. On the other, López-Mielgo et al. (2008) confirm that companies from the food and drink industry show a greater likelihood to implement total quality systems. The underlying assumption of these papers is that firms with a higher technological level are used to working with complex techniques in their production activities and find it less costly to adapt to the requirements of the quality standards. Moreover, they are also in a better position to exploit more quickly the advantages that certification brings.

This research shares this view and analyzes, in a multi-industry setting, how innovation capabilities affect the implementation of HC of TQM. In order to capture the complexities of the concept, innovation capabilities will be defined in a broad manner, including both product and process innovations, as well as R&D and high technological level. This study also looks at the role of a set of resources that complements innovation capabilities and creates better conditions for implementing HC. These valuable resources are size, commercial assets, being a multinational firm and human capital.

The remainder of the paper is organized as follows. Section 2 revisits the literature on the relation between quality and innovation management, and formulates the hypotheses. Section 3 describes the model and the variables. Then, empirical findings are presented in Section 4. Finally, Section 5 discusses the contributions.

2. Theoretical framework

The HC of TQM include practices such as systematic measurement, control of work, standards and statistical procedures that aim to ensure that the manufacturing processes and products satisfy the established requirements. HC are based on high levels of three basic organizational design variables: formalization, standardization, and centralization (Prahogo and Sohal, 2004).

A firm can develop a solid quality assurance formed by the hard components of TQM, but only when it has been evaluated by an independent accredited organization will the firm obtain a quality certification. The firm can then use this certification to signal to the market that its production process control satisfies quality parameters. A large number of different certifications exist but the most widely used at the global level is the ISO 9000 series, developed by the International Organization for Standardization (ISO). The ISO 9000 standards appeared in 1987, and spread rapidly in the 1990s. They are currently a common business practice. Research on ISO 9000 centers, nowadays, on three closely related issues:

(1) What type of factor motivates the decision to seek certification? Market pressure (satisfying customer requirements, complying with legal regulations) or the competitive advantages and internal improvements directly attributed to certification (continuous improvement, waste reduction)? The relative importance of both types of factor depends on the nature and the level of public controls, as well as the market power and marketing strategies of customers. Pressure from powerful organizations, such as multinational companies, distribution chains or even governments, appears to have had a decisive influence on the pattern of diffusion of certification (Guler et al., 2002).

(2) What competitive advantages or internal improvements can firms expect to gain from certification? Certification improves the company's competitive position (Powell, 1995), since it helps the firm differentiate its products and may also enhance or reinforce its reputation. Certification also facilitates access to distribution channels in more favorable conditions and presupposes important transaction cost savings associated with the search for appropriate suppliers and customers, the negotiation of contracts, and their supervision and control.[1] In addition, applying the ISO 9000 standard cuts administration costs and improves coordination and control within the company. The successive revisions of ISO 9000 have taken particular care to ensure that the standard remains compatible with other standardized management systems (e.g., ISO 14000), so they can be used together or even integrated. Finally, certified quality systems help firms to rationalize their production processes and encourage them to introduce organizational changes that result in the following benefits (Brown and Van der Viele, 1995; Tsiotras and Gotzamani, 1996; Rao et al., 1997; Grigg, 1998; Casadeus and Gimenez, 2000; Climent, 2005): consistency of product quality, upgrading in products and services, process improvements, better in-process control, waste reduction, improvements in the company management, information gathering and analysis, human resource development and increased employee awareness, improvement of the relationships within the organization, enhancement in customer and supplier relations, increase in customer satisfaction, and finally, and in most cases, improved productivity.

(3) What is the cost–benefit balance of certification? Obtaining and maintaining quality certification involves both costs and benefits (Dale, 1999). The costs incurred in obtaining and maintaining a certification such as ISO 9000 are both internal (development and implementation of the management system, training programs, start-up costs, annual maintenance costs) and external (registration costs, consulting fees, follow-up visits). Many researchers have attempted to

[1] For example, in the automobile industry ISO is used as a basic structure to which sector requirements and specific standards are added and used to approve suppliers. This does not mean that a supplier that does not possess ISO 9000 certification will be left out of the market. To obtain approval the supplier would need to demonstrate that it has a quality system comparable to ISO, and either the manufacturer or an auditor has to audit the system. This is costly, and it is these costs that exclude the supplier from the market. The ISO-certified supplier avoids incurring such costs every time it seeks approval to supply a new manufacturer, and for those companies that receive many supplier visits and audits, obtaining the ISO standard may reduce supplier audits and quality testing.

evaluate the effect of ISO 9000 certification on profits, by making statistical analyses based on samples of companies and case studies (McTeer and Dale, 1995; Ittner and Larcker, 1997; Easton and Jarrell, 1998; Samson and Terziovski, 1999; Poksinska et al., 2006; Terziovski and Power, 2007).

The first two issues are unproblematic, and the research comes to consistent conclusions. But the findings on the cost–benefit balance of certification are inconsistent and often contradictory. While some studies point mostly to the marketing contribution, others emphasize the internal improvements in organizations (Poksinska et al., 2006). Although no consistent evidence has been found for a direct and immediate relation between obtaining a quality certificate and the various measures of firm performance used (Van der Wiele et al., 2000a, 2000b), the available evidence suggests that the balance of costs and benefits attributable to quality certification differs between companies and depends on factors such as size, management attitude and commitment to quality, and the application of advanced quality management practices associated with TQM (Rainer and Porter, 1991; Rao et al., 1997; Anderson et al., 1999).

Other studies provide supplementary evidence and introduce new explanatory variables relating to the firm's technology and innovation strategy. For example, Vloeberghs and Bellens (1996) describe the experience of implementing ISO 9000 in 290 certified firms in Belgium. Their research shows that high-technology companies (those that are active in innovation, allocate a significant part of their budgets to R&D, and are active in areas such as IT, telecommunications, medicine, pharmaceuticals and biotechnology) have implemented or are implementing TQM and use external quality management consultants more than low-technology firms. High-technology companies and strongly automated organizations also report being more satisfied with their implementation of ISO 9000 than less-automated companies.

Escanciano et al. (2002) analyze the influence of the firm's technological status on the perception of the results from certification in 749 Spanish certified firms. They find that technologically superior firms (companies that report that their technology level is higher than their competitors') seem to be more satisfied with the results of certification. They also observe a positive relation between a high technological level and the firm's advance towards TQM. For their part, López-Mielgo et al. (2008) analyze the determinants behind Spanish firms' implementation of HC. Their empirical analysis uses a sample of 260 firms from the food and drink industry over a period of 9 years. The results show that the factors relating to innovation and technology are the ones that most increase the probability firms will adopt quality control and standardization practices. These authors suggest a sequential pattern of innovation. Firms firstly innovate to satisfy customers and retailers' quality requirements, to comply with the regulation and to overcome international technical barriers to trade, or simply to be proactive gaining competitive advantages through innovation-based strategies. Then, they standardize the process to standardize quality levels. And, finally, they obtain certification to signal this quality and to reduce transaction costs.

On the basis of these theoretical arguments and the previous empirical evidence, it can be assumed that if the firms that are more active in innovation, or R&D, or that have a high technological level, are able to obtain greater benefits from the hard components of TQM, they will have a greater propensity to carry out this type of activity. Being more active in innovation, or R&D, or having a high technological level, will be called innovation capabilities—i.e., the aptitude to generate new or improved products and/or production processes. Innovation capabilities are dynamic capabilities accumulated over time and based on: (1) Transformative capacity, understood as the generation of new knowledge, and profiting from this by means of new innovations (Garud and Nayyar, 1994). This is reinforced by experience: the more innovation there is, the easier it is to innovate (Winter, 2003). That is what we refer to as active in innovation. (2) Absorptive capacity, i.e., the ability to select and obtain valid information from outside the company, to assimilate such information and apply it to company products and processes for commercial processes. R&D investments are the main source of absorptive capacity (Cohen and Levinthal, 1990). R&D plays a critical role in innovation since it functions as the technological gatekeeper in the organization (Jankowski, 1998). Moreover, R&D can be used as an offensive strategy intended to attack competitors, improve market shares, or open up new markets (Lowe, 1995). R&D sometimes changes the rules of the competition, or destroys an existing market and creates a new one (Tushman and Anderson, 1986). (3) Technological level. Employees familiarized with a high technological level and able to use advanced technologies are more receptive to technological changes and more proactive to innovation, especially when the changes are in their own sector (Jaffe, 1986).

Thus, the first hypothesis is as follows:

H1. Firms with greater innovation capabilities (active in innovation, or R&D, or having a high technological level) have a greater propensity to carry out activities relating to the hard components of TQM.

The evidence and the arguments discussed above suggest that possessing some resources in addition to innovation capabilities may be useful for companies involved in standardization and quality assurance processes, because the cost of complying with the standard depends on the efficacy with which it is obtained, which in turn is linked to factors such as firm size, commercial assets, being a multinational firm and human capital.

Previous evidence indicates that there is a minimum size threshold for implementing HC, and that small firms adopt these practices less and they are less successful when adopted (Sanders, 1994; Terziovski et al., 1997; Seddon, 1997; Taylor, 2001). To implement quality management practices, large firms report having to improve internal communication at all levels, and having to improve management and staff understanding of the firm's production process. Small firms, on the other hand, often do not need to make these coordination adjustments because they tend to have good intra-firm communication already. Implementation of ISO 9000 just results in increased paper work and cannot give them any internal benefits, such as the reduction of waste or increased productivity. Internal communication and coordination are inexpensive for small firms, so they have less to gain from quality systems than large firms. Thus, if large firms are more likely to benefit from the HC of TQM, they will probably have a greater likelihood to implement the HC.

With regard to the commercial assets, signaling theory shows that certification is an efficient information system if it is sufficiently costly to obtain, so that it is prohibitively expensive for lower-quality firms (Spence, 1969). For producers, controlling and ensuring quality is a costly process and they will only be prepared to make the necessary investments if they are able to obtain income or profits from that control. To appropriate these rents they need complementary resources such as reputation, trademarks, and market share, which make it possible to obtain economies of scope and synergies by sharing investment between current and future products. In addition, the firm may signal its commitment to quality by various means, such as sunk costs associated with advertising investments and trademarks, or the value of the company's reputation shared by various products and markets. In this case, the company assumes the risk of damaging its reputation in other products and markets if it misuses it in a specific business. Conceivably, only those companies that make the effort needed to standardize and ensure the quality required will be in a position to risk the quasi-rents associated with specific investments in advertising or the value of the reputation in shared markets. The current work attempts to measure these effects through differentiation and diversification variables. The analysis of López-Mielgo et al. (2008) in the food industry demonstrates that commercial assets (differentiation and diversification) increase the likelihood of carrying out standardization and quality control activities.

The participation of foreign capital encourages the importation of advanced techniques and practices in quality management. Companies operating in more than one country are very active in spreading organizational improvements across national boundaries, since they transfer technical and organizational knowledge to their subsidiaries and the other organizations with which they work (Arias and Guillén, 1998).

A high proportion of trained technical employees (including researchers and specialized R&D engineers) and company executives – people who have a greater learning capacity – encourages change in the organizational processes required to implement and obtain maximum performance from the TQM practices, as well as the absorption and assimilation of external technology and the internal production of improvements (López-Mielgo et al., 2008).

So, firms with these elements – large size, valuable commercial assets, multinational scope and human capital intensity – will be in a better position to: (1) reduce the cost of implementing a quality standard and (2) ensure they can recover investments in quality management. So the second hypothesis of this paper is:

H2. Firms in a better position – in terms of size, commercial assets, being a multinational firm and human capital – to reduce the costs of implementing a standard are more proactive in doing so.

The following sections examine additional evidence that will permit either confirmation or refutation of these hypotheses. To this end, an empirical analysis of Spanish manufacturing firms is carried out.

3. The model

As dependent variable, the firms' standardization and quality control activities (S&QC) are taken. They constitute the core element of the HC of TQM. Several reasons justify this choice over ISO, which is used in previous research. First, there is no official centralized record of certificates offering data on ISO 9000 series certification at the firm level, and the available data should be interpreted with due caution since there are doubts regarding their accuracy and inclusiveness. In addition, not all companies with a quality system equivalent to ISO 9000 are actually certified: some companies use the standards as internal documents, while others obtain external certification.

Second, possessing ISO certification does not require making radical changes (and hence improvements) in organizations: it only presupposes "writing down what you are doing and acting accordingly" (Van der Wiele et al., 2000a). Nor does certification necessarily lead to improve the quality assurance in the products or fewer customer complaints (Devos et al., 1996).

Finally, it is also important to consider the proliferation in some European industries of quality assurance standards and schemes that act as alternatives to ISO. For instance, the Codex Alimentarius made a decisive contribution to the development and diffusion of many safety and quality standards currently used in the food industry, such as the HACCP system, internationally recognized as an effective method for guaranteeing food safety (Unnever and Jensen, 1999). Given this diversity, it is preferable to use an indicator that approximates the company's efforts to standardize and control quality, irrespective of whether or not the firm seeks certification, and regardless of its choice from the broad range of quality assurance standards and schemes available if it does decide to obtain certification.

To link the likelihood of implementing S&QC to innovation capabilities and the better position, the following probit model is estimated:

$$\text{Prob}(y_{it} = 1) = \int_{-\infty}^{\beta' x} \phi(t)dt = \Phi(\beta' x_{it})$$

where y_{it} is a 0/1 variable taking value 1 when firm i reports S&QC activities (whether carried out by the firm itself or subcontracted to third parties) and x_{it} represents the vector of explanatory variables (innovation capabilities, better position – size, commercial assets, being a multinational firm and human capital – and control variables). Table 1 describes all the explanatory variables.

Innovation capabilities are modeled including: (1) Innovation experience. This is measured with two variables (Innproduct_{it} and Innprocess_{it}) that capture the firm's past experience in generating innovations. (2) R&D. This is measured using the dummy variable $\text{R\&D}_{it}$, which indicates whether firm i has carried out R&D activities in period t. (3) Technological level. The model resorts to a proxy of the technological sophistication of the manufacturing process: AT_{it} measures the number of advanced technologies (machines and tools for numerical control by computer, robotics, CAD or CAM) of firm i in period t. The use of advanced

Table 1
Definition of explanatory variables.

Innovation capabilities	
$\text{Innproduct}_{it} = 1$ if firm i generates a product innovation in period t (dummy)	
$\text{Innprocess}_{it} = 1$ if firm i generates a process innovation in period t (dummy)	
$\text{R\&D}_{it} = 1$ if firm i's R&D expenditures are positive in period t (dummy)	
AT_{it} (advanced technologies) = 0, 1, 2, 3 or 4 based on number of advanced technologies (machines and tools for numerical control by computer, robotics, CAD or CAM used in production process) of firm i in period t	
Better conditions	
Size_{it} = categorized into 9 dummies by number of employees (10–20; 21–50; 51–100; 101–200; 201–500; >500)	
Commercial assets	
$\text{Differentiation}_{it} = 1$ if firm i promotes and advertises new products in period t (dummy)	
$\text{Diversification}_{it}$ = categorized into 3 dummies for statistical analysis: non-diversified, 2 products, 3 or more products	
$\text{Multinational}_{it} = 1$ if 50% of company capital is in foreign hands	
$\text{Human capital}_{it}$ = no. of qualified employees/total number of employees of firm i in period t	
Control variables	
$\text{Merger}_{it} = 1$ if company i has been through a merger in period t	
$\text{Split-off}_{it} = 1$ if company i has had restructuring, disinvestments or similar business split-off in period t	
$\text{Spin-off}_{it} = 1$ if company i is incorporated in sample as a result of spin-off in period t	
Sector_i = categorized into 18 dummies for statistical analysis:	
1. Ferrous and non-ferrous metals	10. Meat and preserved meat
2. Non-metallic mineral products	11. Food and tobacco
3. Chemical products	12. Beverages
4. Metal products	13. Textiles and clothing
5. Industrial and agricultural machinery	14. Leather and footwear
6. Office and data processing machinery	15. Wood and wooden furniture
7. Electrical and electronic goods	16. Paper and printing products
8. Vehicles, cars and motors	17. Plastic and rubber products
9. Other transport equipment	18. Other manufactured products
Year_t = categorized into 9 dummies for statistical analysis (from 1991 to 1999)	

technologies in the production process is an indicator of the firm's technological level (Beneito, 2001), since employees able to use them will be more receptive to technological changes. Advanced technologies also provide flexibility and efficiency and facilitate the development of innovations.

The variables that capture the better conditions for implementing HC have been applied in different papers (López-Mielgo et al., 2003, 2008; Huergo and Jaumandreu, 2004; Beneito, 2003) that examine these topics and use a similar methodology.

The model includes several control variables. On the one hand, we use three dummies measuring the effects of internal structural changes in companies: mergers, split-offs and spin-offs. On the other hand, it is necessary to add in the specification other variables that do not depend on the firms' decisions, but can affect their S&QC activities: sector dummies to account for the effect of differential features of the sectors considered and temporal dummies to control for factors that vary over time but affect all manufacturing firms, such as generic economic conditions. These temporal dummies also control for any spurious correlation that might result from the underlying time trends in the adoption of quality management practices.

The probit analysis is applied to a panel data. In this way, three types of factors can be controlled for: (1) those that vary over time for firms and are different across firms, such as technological capabilities or size; (2) factors that vary over time but are generally invariant across firms in an industry sample, such as economic conditions or industry demand characteristics; and (3) factors that are relatively invariant within a firm and over time, but vary across firms, such as being a multinational firm.

4. Main findings

The above hypotheses are tested using data from the Spanish official Survey of Industrial Strategic Behavior (SISB) carried out by the Ministry of Industry and Commerce and the SEPI Foundation. This survey involves a sample of more than 2300 Spanish companies for the period 1991–1999. This period covers almost a complete industrial cycle, ranging from the end of a boom in the Spanish economy (1991) to the next recovery (1994–1998), including the short drastic downturn that peaked in 1993 and the economic growth pause of 1995–1996.

The richness of the information at firm level allows us to identify firm-specific resources and capabilities, which generally cannot be observed in the standard accounting data. In addition, the panel format controls for unobservable individual heterogeneity and substantially improves the quality of the econometric results. Finally, the SISB includes a set of decisions, such as mergers, takeovers, and spin-offs, which result in changes of an extraordinary nature in the life of the company and which require controls to ensure comparability of the data.

One of the most noteworthy features of the SISB is its representativeness. The population comprises companies with 10 or more workers overall nationwide. The SISB is representative of Spanish manufacturing companies in terms of sectors and size intervals, combining criteria of exhaustiveness and of random sampling according to the employment level of the companies (Table 2). This means that inferences can be considered globally valid for Spanish manufacturing as a whole (Fariñas and Jaumandreu, 1994). The sector classification was modified later to NACE-CLIO R44, which is used in this paper.

Table 3 shows that the panel includes 2909 firms, of which 992 are observed over the complete period 1991–1999 (9 time observations). The remaining 1917 firms are observed for shorter time spells (from 8 to 1 time observation). Every year almost 2000 companies are observed, and the total number of observations is 16296. For the period as a whole, an average of 43% of the companies confirm that they carry out standardization and quality control. Firms with more than 200 workers do S&QC much more than firms with 200 or less (71% compared to 31%).

Table 2
Percentage of Spanish manufacturing firms covered by SISB by size intervals and industries (CNAE).

CNAE industries	Size intervals				
	10–20	21–50	51–100	101–200	>200
Ferrous and non-ferrous metals	4.3	5.4	4.7	5.0	73.9
Non-metallic mineral products	3.9	4.3	4.8	4.5	61.1
Chemical products	4.9	4.4	5.3	5.1	68.2
Metal products	1.6	3.1	4.3	5.0	71.3
Industrial and agricultural machinery	4.3	3.8	4.0	9.3	76.1
Office and data processing machinery	12.1	10.0	37.5	–	100.0
Electric materials and accessories	4.3	4.6	4.5	9.3	68.7
Electronic materials	4.4	5.3	6.7	26.7	76.2
Vehicles, cars and motors	5.8	4.3	4.7	5.6	71.1
Shipbuilding	3.2	8.4	18.2	37.5	75.0
Other transport materials	7.5	8.0	21.7	27.8	78.6
Precision instruments and similar	4.8	6.5	7.6	15.0	76.5
Food	4.5	4.7	4.8	4.0	63.7
Beverages and tobacco	5.0	5.1	6.8	2.5	60.2
Textiles	4.3	3.9	3.7	6.2	56.9
Leather	4.6	4.8	7.0	14.3	88.9
Footwear and clothing	3.1	4.0	4.0	6.8	79.5
Wood and wooden furniture	2.7	4.7	4.8	7.4	62.5
Paper, paper products and printing	4.2	3.9	3.7	5.0	64.6
Plastic and rubber products	3.2	3.7	1.9	3.9	73.3
Other manufactured products	5.2	6.3	10.5	36.4	77.8
Total manufacturing	3.5	4.2	4.8	6.3	68.1

Source: Fariñas and Jaumandreu (1994).

Table 4 presents the main explanatory group of variables: innovation capabilities. Interestingly, more companies innovate in their processes than in their products (35% and 27%, respectively). In addition, a high percentage of firms do not use any of the advanced technologies considered (numerical controlled machines and tools, robotics, CAD or CAM) (42%). The frequency of firms with three (9%) or four (5%) advanced technologies is very low, even zero in 1992, 1995 and 1999.

Table 5 shows the relation between S&QC and innovation capabilities. S&QC is more likely in firms that realize activities related with innovation and technology. This link is particularly strong in the case of R&D activities: 71% of firms with a positive R&D budget also realize S&QC, while only 28% of firms without R&D do S&QC. Also, the sophistication of the manufacturing process has a significant effect: in companies that use two or more advanced technologies, 60% also realize S&QC, while the percentage falls to 26% in companies using none. This descriptive analysis suggests that the first hypothesis of this work will be accepted. The following section reports the results of the econometric estimation.

To analyze the data we estimate a random-effects probit model, as there is no consensus among academics about how to validate a fixed-effects estimator. Moreover, the parameter ρ – which shows the correlation between the error terms corresponding to the same individual over different periods – is significant. This confirms that the random-effects model is better than a pooled one.

Table 6 reports the results of the bivariate probit model. Some variables – such as size, diversification, sector or year – are formed by a group of dummies. Some but not all of these dummies are significant. Adding additional parameters will always result in a higher likelihood score. However, there comes a point when adding additional parameters no longer makes a significant improvement in the fit of a model to a particular dataset.

Table 3
Standardization and quality control activities.

	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total
No. of firms	1983	1925	1806	1825	1664	1679	1904	1766	1744	16296
% with S&QC = 1	44.78%	43.69%	42.47%	40.93%	42.13%	41.04%	41.75%	47.40%	47.59%	43.54%
Firms with ⩾200 workers	703	636	531	591	536	506	519	507	479	5008
% with S&QC = 1	68.28%	68.71%	68.36%	69.54%	71.64%	72.73%	72.64%	74.36%	74.74%	70.99%
Firms with <200 workers	1273	1288	1274	1233	1125	1172	1381	1254	1262	11262
% with S&QC = 1	31.58%	31.37%	31.71%	27.25%	28.09%	27.30%	30.05%	36.36%	37.24%	31.28%

Table 4
Innovation capabilities.

	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total
Innproduct = 1 (%)	27.33	27.12	26.08	27.23	25.72	26.74	27.52	27.35	27.69	26.99
Innprocess = 1 (%)	36.41	33.66	33.89	35.18	33.83	33.41	36.19	38.00	35.49	35.14
R&D = 1 (%)	36.66	34.81	34.00	35.51	35.28	34.96	34.66	37.88	37.90	35.73
AT (value 4)	4.90	0.00	2.13	5.39	0.00	2.40	3.40	7.91	0.00	5.55
(value 3)	7.20	5.26	1.06	9.01	0.00	2.40	11.42	12.87	12.40	9.41
(value 2)	13.15	3.95	4.26	12.47	0.00	10.40	12.04	15.98	17.36	13.46
(value 1)	30.20	31.58	32.98	29.99	57.14	33.60	30.86	28.10	37.19	29.88
(value 0)	44.55	59.21	59.57	43.14	42.86	51.20	42.28	35.14	33.06	41.70

Table 5
S&QC and innovation capabilities.

	Percentage of firms with S&QC = 1									
	1991	1992	1993	1994	1995	1996	1997	1998	1999	Total
No. of firms	1983	1925	1806	1825	1664	1679	1904	1766	1744	16 296
Innproduct										
1	57.01	56.21	54.99	60.97	59.58	57.68	58.97	64.39	63.35	59.20
0	40.18	39.06	38.05	33.43	36.08	34.96	35.22	41.00	41.55	37.75
Innprocess										
1	57.34	58.71	58.01	60.75	62.88	59.36	58.49	66.77	64.78	60.74
0	37.59	36.10	34.51	30.18	31.52	31.84	32.26	35.53	38.13	34.22
R&D = 1										
1	69.19	68.55	70.03	72.38	71.89	69.51	70.15	73.99	73.98	71.07
0	30.65	30.44	28.27	23.62	25.91	25.73	26.69	31.18	31.49	28.23
AT (value 4)	73.40	No obs.	100	76.84	No obs.	33.33	90.91	75.91	No obs.	75.73
(value 3)	70.29	00.00	100	69.18	No obs.	33.33	59.46	75.34	33.33	69.66
(value 2)	60.71	66.67	25.00	61.36	No obs.	38.46	71.79	60.65	61.90	60.92
(value 1)	49.22	25.00	32.26	48.02	75.00	26.19	38.00	44.76	33.33	45.63
(value 0)	31.26	15.56	10.71	20.89	66.67	20.31	22.63	27.42	35.00	25.92

The likelihood ratio test[2] (LRT) verifies the overall significance of groups of dummies that refer to the same variable. LRT is a statistical test of the goodness of fit between two models. It provides an objective criterion for selecting among possible models. Non-significant variables should be excluded from the initial model L_A, giving way to a new adjusted model L_B. Table 7 shows that all variables are significant to 1%. Thus, in this case, the adjusted model includes all explanatory variables and coincides with the initial model. Added to that, we also carried out two more LRTs for the groups of variables related with the first (technological capabilities) and second (better conditions) hypotheses. In this way, the combined significance of these two groups of variables are tested.

Taken together, Tables 6 and 7 confirm our first hypothesis, showing that innovation capabilities make firms more likely to invest in S&QC. Surprisingly, product innovation has no significant influence on S&QC, while process innovation has a positive and highly significant effect. R&D activities and the technological sophistication of the manufacturing process also increase the likelihood of carrying out S&QC, as expected.

Better conditions as a group also affect the likelihood of implementing S&QC activities, so the second hypothesis can also be accepted. Specifically, firm size and commercial assets have a positive effect. According to the results, larger and more-diversified companies are more likely to carry out S&QC practices. Neither being a multinational firm nor human capital is explanatory.

[2] LRT begins with a comparison of the likelihood scores of the two models, $LR = -2(L_B - L_A)$, and it follows a χ^2 distribution with degrees of freedom equal to the number of additional parameters in the more complex model.

Table 6
Probability of carrying out S&QC.

Dependent variable: S&QC	Coefficient	(*t*)
Innovation capabilities		
Constant	−1.608	(−9.23)
Innproduct	−0.001	(−0.02)
Innprocess	0.351***	(7.48)
R&D	0.663***	(11.90)
AT	0.126***	(5.55)
Better conditions		
Size		
Less than 20	ref.	
From 21 to 50	0.336***	(5.29)
From 51 to 100	0.744***	(8.11)
From 101 to 200	0.794***	(8.69)
From 201 to 500	0.926***	(10.87)
More than 500	0.707***	(6.63)
Commercial assets		
Differentiation	0.145***	(2.57)
Undiversified	−0.099**	(−1.92)
Diversified	ref.	
Very diversified	0.217***	(3.68)
Multinational	0.033	(0.626)
Human capital	0.298	(1.35)
Control		
Merger	0.106	(0.58)
Split-off	0.132	(0.60)
Spin-off	−0.366	(−1.52)
Sector		
Ferrous and non-ferrous metals	0.591***	(2.70)
Non-metallic mineral products	0.320	(1.76)
Chemical products	0.513*	(2.75)
Metal products	0.657***	(3.78)
Agriculture and industrial equip.	0.139***	(0.75)
Office and data proc. machinery	0.178	(0.65)
Electrical and electronic goods	0.616	(3.38)
Vehicles, cars and motors	0.564***	(2.90)
Other transport equip.	0.373***	(1.67)
Meat and preserved meat	0.537	(2.58)
Other food prod. and tobacco	0.556***	(3.16)
Beverages	0.445***	(1.98)
Textiles and clothing	−0.129**	(−0.73)
Leather and footwear	0.021	(0.10)
Wood and wooden furniture	−0.723	(−0.38)
Paper, paper prod. and printing	0.003	(0.02)
Plastic and rubber products	0.508***	(2.77)
Other manufactured prod.	ref.	
Year		
1991	ref.	
1992	−0.265	(−1.26)
1993	−0.231	(−1.23)
1994	−0.172***	(−3.36)
1995	1.243	(1.88)
1996	−0.146	(−0.91)
1997	−0.081	(−0.80)
1998	−0.027	(−0.51)
1999	0.200	(1.31)
Model: RE PROBIT		
Log likelihood = −3180.70		
χ^2 (*p*-value) = 1000.74		
Observations = 16 296 (with 2909 different firms)		
$\rho = 0.269^{***}$ (9.276)		
Likelihood ratio test of $\rho = 0$: 84.80 (0.000)		

t-statistics in parentheses. Asterisks (***), (**) and (*) show statistical significance at 1%, 5% and 10%, respectively.
Note that parameter ρ shows correlation between error terms corresponding to same individual over different periods. It is significant, implying existence of an individual random effect, which confirms that random effects model is appropriate. Likelihood ratio test reinforces this result.

With regard to the control variables, the probability of carrying out S&QC activities varies across industries. Textiles and clothing firms have a low probability of standardization and quality control of the manufacturing process. On the other hand, ferrous and non-ferrous metals, metal products, agriculture and industrial equipment, vehicles, cars and motors, other transport equipment, food products and tobacco, beverages, and plastic and rubber products show a positive probability significant at 1%, while chemical products is also significant but only at 10%. The remaining industries are not significant. The time dummy coefficients are significant as a group, but 1991 is no different from other years, with one exception: the strong downturn that Spanish industry registered in 1993 is reflected in the following year's S&QC. The next recovery and the economic growth pause are not reflected in the data. The impact of corporate restructuring events (merger, split-off, spin-off) also turns out to be unimportant.

5. Discussion and conclusions

This paper aims to examine whether the most innovative manufacturing firms tend also to apply standardization and quality control practices. A review of both the theoretical and empirical literature suggests a positive relation between both policies, since high innovation capabilities may reduce the costs of implementing a quality standard and ensure the profitability of the investments needed for controlling quality.

The results show that innovation increases the likelihood of investing in hard components of TQM, so Hypothesis 1 is accepted. This finding is coherent with previous studies like Vloeberghs and Bellens (1996), Escanciano et al. (2002) and López-Mielgo et al. (2008). Particularly revealing is the fact that while product innovation has a non-significant influence on standardization and quality control activities, process innovation has a positive and highly significant effect. There are several reasons that can explain this result. Firstly, changes in product design or presentation are an important aspect of product innovation in some industries. They may add utility for the consumer and match market requirements more closely, but in themselves do not necessarily make significant changes to the quality management systems. Secondly, radical product innovations in most industries are mainly consequences of fundamental transformations in process technology, such as for example in the food industry (Wilkinson, 1998). The use of advanced technologies and R&D are also positive and significant.

The empirical findings also demonstrate that the likelihood of doing S&QC activities depends greatly on the profile of the firm, and confirm the second hypothesis of the paper. Companies' S&QC activities differ due to factors such as size and availability of complementary assets (reputation and distribution networks). Firms that have the resources and capabilities needed to appropriate the benefits generated by a competitive advantage in quality and/or reduce the costs of implementing a quality standard, have greater incentives to develop the hard components of TQM. López-Mielgo et al. (2008) reach the same conclusions in the food sector, and the results are coherent with the analysis of Sanders (1994), Seddon (1997) and Poksinska et al. (2006).

Industry effects are significant, so the characteristics of the manufacturing process and the demand are likely to influence the propensity to invest in standardization activities. In fact, in some industries, such as vehicles, cars and motors, food products, or beverages, the cost of obtaining information about the quality of the products is high. In these cases companies should offer their customers not only a superior quality but also the certainty of a superior quality. This entails standardizing their operational processes to obtain certificates that vouch for the promised

Table 7
LR test.

	Diversification	Size	Sector	Year	(1)	(2)
L_B	−6703.1	−6875.7	−6792.5	−3191.8	−6792.8	−6962.5
L_A	−3180.7	−3180.7	−3180.7	−3180.7	−3180.7	−3180.7
LR_χ^2 (λ)	7044.9	7389.6	7223.7	22.2	7224.2	7563.7
df	2	5	17	8	4	11
Critical value χ^2 to 1%	9.21	15.08	33.41	20.09	13.28	24.72
Sig.	0.000	0.000	0.000	0.004	0.000	0.000

(1) Group of variables related with technological capabilities.
(2) Group of variables related with better conditions.

quality. In this kind of industry, certification leads to important transaction cost savings associated with the search for appropriate suppliers and customers, the negotiation of contracts, and their supervision and control (Holleran et al., 1999).

The economic cycle does not have a significant effect, nor do corporate restructuring events (merger, split-off and spin-off). It would be reasonable to assume that S&QC is a rather stable activity, whose level is determined by considerations other than the economic cycle or corporate events.

Despite the widely held and empirically supported idea that companies centering their efforts on the search for quality assurance drown creativity and hence innovation, this paper provides empirical support for the recommendation to manage quality and innovation as not conflicting activities, as authors such as Benner and Tushman (2002) and Prahogo and Sohal (2006b) argue. The results confirm that solid innovation capabilities (built on past innovation, R&D, and the use of advanced technologies) increase firms' propensity to implement elements of HC of TQM. This appears to confirm the sequential pattern of innovation that López-Mielgo et al. (2008) find in the food sector, in which quality standardization follows more fundamental or basic innovations.

As far as managerial implications are concerned, it is important to emphasize that quality and innovation departments must overcome the traditional conflict between both activities. Specifically, they should cooperate in the early implementation of quality management tools in order to ease the standardization of new products and processes.

Finally, although the following generalization is beyond the scope of this paper, we might reasonably suppose that firms with better innovation capabilities will be proactive in the adoption of standardized management systems. It has been shown that innovative companies are first movers in the application of standardization and quality control practices. But there is a strong possibility that the implementation of other standardized tools (for environmental management, health and safety management or corporate social responsibility) is associated with innovation capabilities. In any case, further research would be needed in order to verify this suggestive link.

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