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11 **The intervening effect of business innovation capability on**
12 **the relationship between Total Quality Management and**
13 **technological innovation**
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The intervening effect of business innovation capability on the relationship between Total Quality Management and technological innovation

Abstract

The growing diffusion and acceptance in the business world of Total Quality Management (TQM) has provoked greater interest on the part of academia. Although fundamental questions focus on how the different dimensions of TQM can bring about better business performance, a more recent recurring issue pertains to the relationship between TQM and technological innovation and whether technological innovations might provide a source of competitive advantage. Unfortunately, from both theoretical and empirical perspectives, the relationship between TQM and technological innovation appears contradictory and complex. This paper argues that the relationship might be better understood from the contingent perspective of strategic management and thus proposes a multidimensional intervening variable in the relationship, called Business Innovation Capability (BIC). An empirical study of 105 Spanish industrial firms reveals that the effect of some business practices suggested by TQM on technological innovation can be better understood when BIC dimensions are taken into account.

Key Words: total quality management; business innovation capability; technological innovation.

1. Introduction

The concepts of quality and innovation have become guiding elements for what, in the business world, is known as management excellence. That is, they constitute the centre of ongoing discussion and a strategic management orientation for formulating and implementing objectives, policies and performance. Quality and innovation, as guides for managerial activity, have been nourished by and spread from pragmatic positions of business consulting to become true management models, and thus, the concepts have moved from being simple attributes of

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3 goods and services to become conceptual nuclei of what currently is known as Total Quality
4 Management (TQM) and innovation management. Both elements fall within the operations
5 management area, which can increase a firm's competitive advantage (Garrido et al. 2007).
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12 However, though modern business management models of excellence consider quality
13 and innovation objectives simultaneous and complementary, in general, business practice first
14 incorporates the concept of quality management and then gradually integrates innovation. This
15 path receives attention from different theoretical perspectives, including the resource-based and
16 dynamic capabilities (RBDC) view of the firm, which explains the shift from product attributes
17 to management models by considering how firms generate organizational resources that offer
18 sources of competitive advantage (Rumelt 1984; Barney 1986; Peteraf 1993). In addition, the
19 RBDC view uses an evolutionary perspective to explain this change in management priorities as
20 a path dependence and accumulation process, in that the quest for innovation performance
21 requires greater organizational complexity than that for quality (Foss 1993; Teece et al. 1997;
22 Hodgson 1998).
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38 The intense dissemination of TQM as a business management model, especially for
39 medium and large firms, prompts a recurring academic question about the effects of TQM on
40 business performance. Although a unanimous and consistent answer to this question remains
41 in-existent, most scholars have arrived at the conclusion that TQM positively affects business
42 performance (Sousa and Voss, 2002; Kaynak 2003). Paradoxically, despite the incorporation of
43 innovation into management excellence models based on TQM and though consensus states that
44 innovation offers a principle source of sustained competitive advantage, research into the
45 relationship between TQM and innovation performance remains scarce (Flynn 1994; Prajogo
46 and Sohal 2003, 2004; Singh and Smith, 2003).
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This absence of empirical verification appears even more surprising if we reflect on the
following comments by a quality 'guru', W. Edwards Deming: 'Ultimately, management's job

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3 is to hone the entire system so that it is capable of making the leap from continual improvement
4 to continual innovation in whole new product categories the customer has never even
5 contemplated' (qtd. in Gabor 1990). Evidently, from even the initial conception of quality-
6 focused management, practitioners foresaw that fostering innovative practices and better
7 performance would permit the construction of a path from continuous improvement to
8 continuous innovation. In other words, TQM should foster technological innovation.
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19 Empirical literature offers contradictory conclusions. Whereas work by Flynn (1994)
20 and Prajogo and Sohal (2003, 2004) indicates a positive relationship between TQM
21 implementation and technological innovation, research by Singh and Smith (2003) and
22 Terziovski and Samson (1998) finds no empirical evidence that TQM promotes better
23 performance in business innovation. The debate has been settled from a theoretical perspective
24 by distinguishing two types of TQM practices: those associated with traceability, follow-up and
25 quality assurance, labelled Total Quality Control (TQC) practices, and those emphasising
26 people's work, internal and external relationships and human resource management, called
27 Total Quality Learning (TQL) practices (Sitkin et al. 1994). That is, TQM comprises two
28 distinct emphases: a *hard* focus on efficiency and a *soft* concentration on learning. In turn, the
29 solution to divergences in empirical results pertaining to the relationship between TQM and
30 technological innovation entails a weak and even negative relationship when considering hard
31 TQM practices but a positive, strong relationship for soft TQM practices (Prajogo and Sohal
32 2001, 2003). These empirical results also emerge from the relationships between TQM and
33 other employee and manufacturing performance metrics (Challis et al. 2005).
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54 However, the problem with this explanation is that TQM generally is broadcast as an
55 integral philosophy, a 'package' of management principles that does not differentiate at the time
56 of implementation between hard and soft aspects (Ahire et al. 1996; Dow et al. 1999; Samson
57 and Terziovski 1999). Hence, those studies that find a significant relationship between TQM
58 and business innovation cannot have been based solely on firms implementing soft practices and
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3 those that find no significant evidence do not coincide only with firms implementing hard
4 practices. Furthermore, studies that employ a broad scope and specifically work to determine
5 the success factors of innovative firms indicate that many of the so-called hard TQM practices
6 support better innovation performance (e.g. Utterback 1971; Freeman 1982; Maidique and
7 Zirger 1984; Delbecq and Mills 1985).

16 Within this conceptual and theoretical dilemma, this article poses an alternative
17 explanation of the relationship between TQM and technological innovation. According to the
18 contingent perspective of strategic management (e.g. Fry and Smith 1987), though TQM
19 implementation constitutes a necessary precondition of greater technological innovation
20 (universalist perspective), it is not sufficient; therefore, contingent variables alter, intensify or
21 mediate the relationship. In particular, Business Innovation Capability (BIC) represents an
22 important contingent variable. The BIC takes a functional form of an interactive type, if
23 conceived of as a complementary asset to TQM, or a mediation type, if we were to accept the
24 simple idea, based on the theoretical perspective of the RBDC, that to innovate, a firm requires
25 the capability for innovation. We therefore explore which of these roles the BIC plays.

39 The paper consists of four more sections. In the next section, we present different
40 alternatives for the relationship between TQM and technological innovation and articulate them
41 in the form of research hypotheses. The methodology and data analysis appear in the third
42 section, and we discuss the results in the fourth section. Finally, we end with a summary of the
43 main implications of this research.

44 **2. Relationship between TQM and technological innovation**

45 ***2.1. A universal-type relationship***

46 An important line of research focuses on analyzing the effects of TQM on business
47 performance (Sousa and Voss 2002; Kaynak 2003). Although such research recognizes that no
48 robust and consolidated evidence about the positive relationship between TQM and business
49 performance exists, it is clear that the positive relationship between TQM and business
50 performance is not robust and consolidated.

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3 performance exists, it has reached consensus regarding the empirical validity of a positive effect
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5 of TQM on operational-type performance, such as productivity, flexibility, on-time delivery of
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7 goods and services, quality and customer satisfaction in general (Kaynak 2003; Rahman and
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9 Bullock 2005).
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14 Although the objectives and performance of technological innovation are not included
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16 as generic competitive priorities in a great part of operations management research, these being
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18 essentially efficiency, flexibility, quality and delivery time (Wheelwright, 1984; Corbett &
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20 Wassenhove, 1993), they are considered to be emerging research topics and are becoming a
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22 growing competitive priority for operations management (Pannirselvan et al., 1999). Therefore,
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24 by analogy, the best practices fostered by TQM should have a positive influence on
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26 technological innovation, in the form of operational business performance.
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31 In turn, and considering that the implementation of TQM best practices preserves the
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33 spirit postulated by Deming of moving from continuous improvement to continuous innovation,
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35 we posit a universal-type relationship between TQM and technological innovation, as in the
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37 following working hypothesis:
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42 *Hypothesis 1:* The implementation of business practices suggested by TQM has a
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44 positive and direct effect on technological innovation.
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49 Despite this reasoning, our review of the scarce literature on this topic reveals that
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51 empirical results both support and deny the proposed relationship (Flynn 1994; Gustafson and
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53 Hundt 1995; McAdam et al. 1998; Terziovski and Samson 1998; Prajogo and Sohal, 2003,
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55 2004; Singh and Smith, 2003). Arguments to justify these contradictory results often address the
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57 way the TQM 'program' is implemented and posit that the kind of TQM practices on which the
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59 firm focuses can influence technological innovation (Sitkin et al. 1994; Dow et al. 1999;
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Martínez-Lorente et al. 1999; Wang and Ahmed, 2002). But it is also possible that the TQM

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3 program represents a contingent subject and that the nature and intensity of its effects on
4 technological innovation depend on and may be explained by certain contextual circumstances.
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6 For example, in line with the RBDC view, to obtain better innovation performance, a BIC must
7 first exist, fostered by a philosophy of total quality (Perdomo-Ortiz et al. 2005). It is thus
8 consistent to argue that the relationship between TQM and technological innovation may be
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10 contingent on building BIC.
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18 **2.2. Contingent relationships**

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20 Both studies of the relationship between TQM and business performance and those
21 focusing specifically on the effects of total quality practices on technological innovation
22 recognize the possibility of a contingent-type relationship (Nowak 1997; Prajogo and Sohal
23 2001). That is, the effects of TQM on performance are not independent of the context in which
24 the program is implemented; thus, no best management practices focused on quality actually
25 promote innovation.
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36 The theoretical perspective of contingency or strategic fit identifies three broad factors:
37 organizational structure, competitive strategy and competitive environment (Van de Ven and
38 Drazin 1985; Prescott 1986; Fry and Smith 1987; Venkatraman 1989). For the specific case of
39 the relationship between TQM and technological innovation, literature suggests that it may be
40 contingent on the type of organizational culture, the type of competitive strategy in the firm and
41 the level of sectoral and competitive dynamism. Likewise, but with a more exploratory
42 approach, other studies identify as contingent variables knowledge management, organizational
43 learning, research and development activities and technology and product cycles (Nowak 1997;
44 Martínez-Lorente et al. 1999; Haner 2002; Wang and Ahmed, 2002).
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57 In accepting the contingent perspective as relevant, we consider that the relationship
58 between TQM and technological innovation may be subject to strategic fit that originates in a
59 critical contingency factor represented by the BIC. This concept, already utilized in classic
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3 literature on innovation theory and defined as a firm's skill in successfully adapting or
4 implementing new ideas, processes or products (Burns and Stalker 1961), has taken on new
5 theoretical relevance since the emergence of the RBDC approach (Tidd et al. 1997). Although
6 no consensus exists about how to understand and measure innovation capabilities, literature
7 deals with the same concept using different terms, such as absorptive capacity, organizational
8 innovation, innovative organizations or innovativeness. With respect to how to measure this
9 capability, two significant trends exist: an expression of the performance or the set of activities,
10 practices and behaviour that precedes performance as potential for action.
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23 According to this theoretical perspective, the generation of competitive advantage
24 depends on the accumulation of strategic resources and capabilities, the latter of which are
25 understood as those that are imperfectly imitable by competitors (Rumelt 1984; Barney 1991).
26 The BIC fulfils the criteria to be considered a source of competitive advantage and is thus
27 strategic for firms (Rumelt 1984; Barney 1986, 1991; Grant 1991). We argue that BIC is a
28 critical contingency factor in the relationship between TQM and technological innovation with a
29 moderating functional form or alternatively a mediating functional form, as we outline in Figure
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51 *The BIC as a moderating variable.* Strategic fit through moderation suggests that the
52 relationship between TQM and technological innovation varies as a function of the different
53 levels that the BIC reaches. An interaction between TQM and BIC alters the direction or
54 intensity of effects on technological innovation. Three types of arguments can be posed for
55 considering the BIC as a moderating factor. First, work by Imai (1986) considers that
56 continuous improvement (*Kaizen*) is not a substitute for innovation, and that rather, it sets the
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3 basis for implementing and suitably exploiting radical innovations. If we emulate Imai's
4 argument, the interaction between continuous improvement (TQM) and innovation skills (BIC)
5 strengthens the effects on technological innovation.
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12 Second, strategic objectives of quality and innovation might be considered
13 complementary, not substitutes. After the appearance of work by Porter (1985), which defends
14 the inconsistency of simultaneously seeking strategic objectives of cost leadership (quality in
15 the restrictive sense) and differentiation leadership (innovation as an instrument), an intense
16 academic debate led to the acceptance of the possibility that firms engage in parallel quests for
17 efficiency and differentiation (Hill 1988). Thus, between the strict quest for efficiency and that
18 for innovation practices as instruments of differentiation, their interaction may achieve greater
19 levels of technological innovation.
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32 Third, derived from the existence of complementary assets for attaining competitive
33 advantages, as suggested by the RBDC view and considered as a mechanism of imperfect
34 imitability (Rumelt 1984), if firms consider TQM programs as an ideal path for attaining
35 competitive advantages but fail in them, a complementary resource or asset may be needed. For
36 the relationship we discuss, literature identifies a so-called 'organizational culture' (Powell
37 1995; Nowak 1997). The organizational culture necessary for the TQM program to succeed in
38 innovation can be assimilated with BIC practices. Therefore, the interaction between TQM and
39 BIC, within the contingent relationship with respect to technological innovation, can be
40 understood as the search for complementarity among 'assets'.
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54 In short, the relationship between TQM and technological innovation may reflect a
55 relationship of contingency, with BIC as the moderating variable. It therefore makes sense to
56 verify whether the following working hypothesis applies:
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3 *Hypothesis 2: The BIC moderates the relationship between the implementation of*
4 *business practices suggested by TQM and technological innovation.*
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10 *The BIC as a mediating variable.* The second contingency approach suggests that
11 strategic fit occurs because of a mediation effect of the BIC on the relationship between TQM
12 and technological innovation. In other words, the BIC works as a mechanism of intervention
13 between the two variables and functions through an indirect effect that accounts for a significant
14 part of the relationship between TQM and technological innovation.
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22 Arguments supporting this relationship have been fuelled by the evolutionist view of
23 RBDC (Teece et al. 1997; Foss 1998). In essence, firms build different types of dynamic
24 capabilities to create competitive advantage by following a path of accumulation and learning.
25 A dynamic capability in this sense is defined as ‘a learned and stable pattern of collective
26 activity through which the organization systematically generates and modifies its operating
27 routines in pursuit of improved effectiveness’ (Zollo and Winter 2002, 340).
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38 Taking up the conceptual framework of evolutionary theory and from an analytical
39 perspective of the evolution of production systems, Bell and Pavitt (1993) suggest that firms
40 build technological capabilities by following patterns of accumulation that, through learning
41 processes, modify their technological resources, routines and activities. In synthesis, they
42 consider that firms draw paths of learning and accumulation of technological capabilities. As a
43 consequence, and according to the degree of complexity of the activities and routines involved
44 in the production systems, technological capabilities progress from basic production to
45 innovation capabilities. Although in some periods, basic and advanced technological
46 capabilities overlap, depending on whether the competitive environment is dynamic or stable, in
47 general, firms move forward along a path of accumulating technological capabilities.
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Therefore, considering the concept of dynamic capabilities and paths of accumulation in production systems, firms that implement a TQM program may enter a path of accumulation of technological capabilities that improves their production capabilities and thus provides a basis for building innovation capabilities. In turn, and according to the RBDC view, the firm achieves innovation performance because it has the capability to do so. In terms of strategic fit, the BIC intervenes in the TQM–technological innovation relationship as a mediating variable, which leads us to pose our third working hypothesis:

Hypothesis 3: The BIC mediates the relationship between the implementation of business practices suggested by TQM and technological innovation.

3. Methodology and analysis

3.1. Data

To test the hypotheses, we take as an objective population Spanish firms with 100 or more employees in the industrial sectors of industrial machinery and equipment and instruments and related products (standard industrial classification codes 35 and 38), which are usually inclined toward developing innovation processes. According to the European Commission (2003), these sectors have high and medium high intensity in R&D expenditures. We obtained an initial list of companies from the Dun & Bradstreet census of the 50,000 largest Spanish firms. After excluding firms that had closed or changed activity, a total of 220 firms remained in the list, 185 of which belonged to the machinery sector and 35 to the instrument sector. To collect information, we sent a questionnaire by mail to all these companies after conventional pre-tests conducted in both academic and business environments. After intense telephone back-up work, we obtained a response rate of 47.7%, equalling 105 valid questionnaires.

3.2. Measurements

Total Quality Management (TQM). To measure TQM, we employ the measurement instrument developed by Flynn et al. (1994), which distinguishes seven dimensions derived

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3 from 63 items, and adapt it to one of six scales (dimensions) and 24 items with a seven-point
4 Likert-type response format. This adaptation is eminently practical; the questionnaire addressed
5 to firms had to contain measurement elements for both quality and innovation, and maintaining
6 the number of items to measure both concepts was problematic in terms of both questionnaire
7 effectiveness and its influence on the response rate.
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16 We assess the measurement instrument using the three-stage methodology suggested by
17 Nunnally (1978) and used by several studies that build prior TQM instruments (e.g. Flynn et al.
18 1995; Ahire et al. 1996; Black and Porter 1996; Saraph et al. 1989). The summarized results
19 appear in Table 1. To evaluate the unidimensionality of the measurement scales, we conduct
20 principal component analysis for each scale and, on the basis of the results, eliminate three
21 items. Cronbach's α serves to evaluate the reliability analysis of the TQM measurement scales
22 and indicates values higher than 0.6 for all scales, which proves a suitable level of internal
23 consistency (Lord and Novick 1968; Nunnally 1978; Jones and James 1979). To evaluate
24 construct validity, we consider the factor loadings of each item of the different scales. The
25 criterion for identifying the critical loading value emerges from calculations based on the
26 sample size of Hair et al. (1999), which for this study is calculated as a critical factor loading of
27 0.55 with a significance level of 0.05. As we show in Table 1, all items load above this value,
28 except for one (on the product design scale) that had a factor loading lower than 0.55. However,
29 we retain this item for practical reasons and because of its theoretical relevance. According to
30 Hair et al. (1999), an item loading between 0.40 and 0.50 has important practical, if not
31 statistical, significance if the sample is larger than 100 observations. Moreover, implementing a
32 TQM philosophy promotes the importance of quality over costs in product design.
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Business Innovation Capability (BIC). Following a similar approach, we adapt the measurement instrument designed by Tang (1999) to measure BIC. Most previous measures of innovation as a dynamic capability design scales for business consulting and do not employ the rigorous perspective of academic empirical research. Tang (1999) provides an exception; we design an instrument consisting of six scales and 23 items with a seven-point Likert-type response format on the basis of the nine scales and 46 items offered by this author.

Our evaluation of the measurement instrument for the BIC follows the same procedure as that for the TQM measurement instrument. We provide the results in Table 2. We first verified the unidimensionality of each scale, which required an adjustment to the number of items, and eliminated three items. The reliability and validity of the instrument are verified; the Cronbach's α are greater than the critical value of 0.6, and the factor loadings are greater than 0.55 for all items.

INSERT TABLE 2 ABOUT HERE

Technological innovation. To measure innovation performance (technological innovation), we derive a measurement scale with four items that represent success in innovation (see Table 3), similar to previous literature (e.g. Schroeder et al. 1989; Chiesa et al. 1996; Hollenstein 1996; Subramanian and Nilakanta 1996; Tidd et al. 1996; Galende and de la Fuente 2003). Each respondent rated his or her company's position compared with that of its main competitors on a five-point scale (1 = very inferior, 3 = similar, 5 = very superior). This measurement approach, based on relative perceptions, offers a suitable and reliable alternative to objective measurements (Dess and Robinson 1984). All measurements loaded onto a single factor with weightings greater than 0.55 (critical value according to Hair et al., 1999) and Cronbach's α well above 0.60 (see Table 3).

INSERT TABLE 3 ABOUT HERE

3.3. Hypotheses testing

To test Hypothesis 1, regarding the universal nature and direct effect of TQM on technological innovation, multiple regression analysis is the most appropriate technique. To avoid problems of interpretation deriving from the collinearity between variables, we chose to study seven models with technological innovation as the dependent variable. Each of the six TQM dimensions was incorporated, respectively, into the first six models. All the dimensions were incorporated into the seventh model, but their entry was conditioned by a stepwise procedure. This way, only those dimensions capable of explaining something about innovation performance that the rest of the priorities cannot explain are entered into the model. That is, the procedure not only allows us to identify whether the TQM dimensions are capable of explaining a significant part of technological innovation, but also allows us to identify which dimensions have greater explanatory power (seventh model). Table 4 shows the results obtained from the estimation of these models. In this case, only the human resource management dimension appears to have a positive and significant effect on technological innovation (see model 5) and then this is the only dimension entering in model 7. As in other studies that attempt to explain innovation performance or innovative behaviour (e.g. Braga and Willmore 1991; Furukawa and Goto 2006), the predictive power (R^2) of the models is low, because innovation depends on many factors and circumstances other than those studied herein (Kumar and Saqib 1996; Galende and Suárez 1999; Kannebley et al. 2005).

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To test Hypothesis 2, pertaining to the existence of a moderated contingent relationship between technological innovation and TQM, we perform moderated regression analysis. For each pair of dimensions TQM_i and BIC_j , we estimate three regression models: (1) considering TQM_i only as the independent variable, (2) including BIC_j as a new independent variable and (3) incorporating the interaction effect between TQM_i and BIC_j . The existence of a moderating effect of BIC_j on the relationship between technological innovation and TQM_i depends on whether the increment of the predictive power (R^2) of model 3 with respect to model 2 is significant and/or whether the coefficient of the interaction term $TQM_i \times BIC_j$ is significant (Jaccard et al. 1990).

Table 5 shows those cases (out of the 36 pairs of dimensions) for which a moderating effect was found. The moderating effects of BIC are significant only for the relationship between technological innovation and the process management dimension of TQM. Specifically, the relationship between technological innovation and the process management dimension (TQM_3) shows to be negatively moderated by four dimensions of BIC (i.e. planning and management commitment - BIC_1 -, projects - BIC_3 -, knowledge and skills - BIC_4 -, and external environment - BIC_6 -).

INSERT TABLE 5 ABOUT HERE

Finally, to test Hypothesis 3, regarding the intervention of BIC as a link between TQM and technological innovation, we use structural equation modelling to estimate the bottom model in Figure 1 for each pair of dimensions TQM_i and BIC_j . However, this hypothesis makes sense only for those TQM dimensions that showed a direct effect on technological innovation (i.e. just for TQM_5) since a variable cannot mediate a relationship if this relationship does not

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3 exist (Judd and Kenny, 1981; Baron and Kenny, 1986). Figure 2 graphically shows the results
4 of this analysis for the case of TQM₅ and BIC₃. Table 6 shows the goodness of fit indexes and
5 the standardized coefficients for the six estimated models (one for each dimension of BIC as
6 mediating variable between TQM₅ and technological innovation). Although fit is poorer for
7 BIC₂ and BIC₆, the results support the idea that the effect of TQM₅ on technological innovation
8 is mediated by the dimensions of BIC.
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21 INSERT FIGURE 2 AND TABLE 6 ABOUT HERE
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27 **4. Discussion of results**

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29 The different theoretical and empirical approaches to the relationship between TQM and
30 technological innovation yield interesting results. In the first place, we find that not all the
31 business practices integrated within the concept of total quality have a positive and significant
32 effect on technological innovation performance and that we cannot therefore talk of a
33 comprehensive influence of the TQM approach on technological innovation but of specific and
34 fine links between these two elements. Indeed, only total quality practices associated with
35 human resource management shows a positive effect on technological innovation (Table 4).
36 This result in particular has been confirmed by recent studies that find a direct and positive
37 relationship between human resource management practices and technological innovation
38 (Laursen and Foss, 2003; Lau and Ngo 2004). Moreover, the characterization of innovative
39 firms indicates which TQM-related human resource practices, such as emphasis on team-work,
40 training and work motivation, represent recurrent traits in the type of firm that enjoys superior
41 performance in innovation (Cooms and Rosse 1992; Cascio 1996; Gómez-Mejía and Saura
42 1996; Hybels and Barley 1996; Balkin et al. 2000).
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3 In short, though TQM as a business management model cannot be viewed as widely
4 linked to technological innovation, it contains a set of best business practices related to human
5 resource management that promotes better innovation performance. Thus, we find partial
6 support for hypothesis 1.
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14 Furthermore, as the results in Table 5 indicate, we find limited evidence regarding the
15 existence of a moderating effect of BIC on the relationship between TQM and technological
16 innovation. The only statistically significant, though negative, interaction effect is that of the
17 process management dimension of TQM with different dimensions of BIC. This result suggests
18 that the emphasis on the control and improvement of processes, in parallel with management
19 practices of innovation—especially those related to project planning, formulation and
20 assessment, developing new knowledge and skills and relating external cooperation—may have
21 a negative effect on technological innovation. That is, a positive relationship between TQM and
22 technological innovation is not promoted by BIC and sometimes even the contrary can happen.
23 Thus our analysis does not support hypothesis 2.
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38 This result may imply that quality and innovation are sequential, rather than
39 complementary, priorities. Prajogo and Sohal (2003), in taking up the approach of Nowak
40 (1997), find empirical evidence of the impact of TQM on quality and innovation performance
41 and, in particular, the existence of sequentiality in achievement, namely, primary effects on
42 quality and secondary effects on (process and product) innovation. Thus, the accumulation and
43 learning paths of firms over time seem to provide a more plausible explanation for the presence
44 of links between quality and innovation. From this perspective, Imai's (1986) proposal about the
45 existence of processes of continuous improvement, as support for innovation practices and
46 performance, appears effective only within a time framework and therefore requires maturation
47 and learning processes over time.
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Finally, empirical evidence indicates that the effects of TQM-based human resource management practices on technological innovation take place because of the potential of these practices to build BIC. The results of the structural equation modelling acceptably confirm the existence of a sequential causal order or mediation between this dimension of TQM and technological innovation (Figure 2, Table 6), that is, we find support for hypothesis 3 as far as the human resource management practices suggested by TQM are taken into account. Thus, there is not a single level of dependence between TQM and technological innovation, as a universal or direct relationship might imply, but rather at least two levels of dependence generated by the need to build a BIC to achieve a positive impact on the levels of technological innovation. In short, empirical acceptance of the existence of strategic fit due to the mediation effect of BIC on the previously identified link between TQM and technological innovation provides a good reason to think that accumulation paths of learning about technological capabilities exist in firms (i.e. from basic production capabilities to complex innovation capabilities).

5. Conclusions

5.1. Theoretical implications

This article clarifies the ongoing debate about the relationship between the practices associated with TQM models and innovation performance. A theoretical point of view poses arguments both in favour of and opposed to the relationship between TQM and technological innovation. In particular, some theoreticians postulate that attaining performance in innovation does not constitute a portion of the TQM perspective, understood as an integral management model. As a consequence, its scope would be limited to achieving customer satisfaction, and its repercussions would affect only business operations and financial performance. Alternatively, more recent trends suggest the concept of continuous innovation, similar to TQM's principle of continuous improvement, to postulate that the management models focused on total quality promote better performance in innovation, in combination with those principles associated with continuous improvement, customer orientation and workplace integration.

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Extant empirical literature on the relationship has yielded divergent results, so this article provides an alternative explanation for the relationship between TQM and technological innovation. As we show, there are no identical effects of all the TQM practices on innovation performance. Whereas human resource management practices suggested by TQM show a positive effect on innovation performance, control and improvement practices can worsen performance when combined with certain innovation management practices. Furthermore, evidence also indicates that TQM-based human resource management practices are proactive for the building of a BIC, which, according to the RBDC view, offers a basis for technological innovation. Thus, we find a mechanism of transmission from TQM to innovation performance.

This idea of a mechanism of intervention and transmission between TQM and technological innovation is based on a contingent or strategic fit approach. Although it has appeared briefly in the few theoretical papers pertaining to the relationship between quality and innovation, fit as mediation has not been postulated previously. Theoretical support for contingent fit by mediation emerges from RBDC theory, which suggests accumulation paths of strategic capabilities for attaining competitive advantages. Therefore, evidence of an intervention mechanism between some TQM practices and technological innovation enables us to suggest that firms evolve by starting with the formation of basic production capabilities, encouraged and improved by certain TQM practices, and then move to complex innovation capabilities, fostered by practices associated with BIC.

From another perspective, learning curves in firms start with the prioritization of strategic objectives and their sequential structure. For example, as suggested by Prajogo and Sohal (2003), firms evolve from objectives and quality performance to objectives and innovation performance.

5.2. Managerial implication

Our results clearly indicate that firms cannot consider TQM simply a passing administrative fashion or a panacea for achieving sustainable competitive advantage over time. Rather, TQM fosters accumulation paths of technological capabilities through its human resource management practices. Therefore, TQM cannot be dismissed as just an administrative trend, because it provides a typical organizational resource on which firms may build a durable competitive advantage.

Managers can find in TQM human resource practices a tool to promote innovation capabilities and improve innovation performance. They should also understand the logical sequence between quality objectives and innovation objectives. In other words, firms must be able to evolve from quality control approaches to those centred on continuous learning.

5.3. Limitations and future lines of research

The limitations of this research mainly derive from our use of a cross-sectional sample to test the hypotheses pertaining to relationships of causality. We need to find alternative methods for empirical measuring and testing, particularly when seeking to evaluate dynamic relationships that stem from the RBDC view. From this perspective, it is necessary to resort to case study, panel data or time-series methodologies.

Further research might explore the multi-dimensional nature of business performance and its relationship with TQM and BIC, particularly by testing hypotheses of sequentiality for specific objectives and their complementary nature. Finally, and following the recent theoretical inclination to assume a complex relationship between quality and innovation, it would be worthwhile to demonstrate new relationships of contingency that consider both classic variables (i.e. strategy, structure, environment) and variables more specific to the relationship between TQM and technological innovation, such as organizational learning, intellectual capital or specific research and development activities.

References

- Ahire S., Golhar, D., and Waller, M. (1996). Development and validation of TQM implementation constructs. *Decision Sciences*, 27(1), 23-56.
- Balkin, D.B., Markman, G.D., and Gómez-Mejía, L.R. (2000). Is CEO pay in high technology firms related to innovation? *Academy of Management Journal*, 43(6), 1118-1129.
- Barney, J. (1986). Organizational culture: Can it be a source of sustained competitive advantage? *Academy of Management Review*, 11, 656-665.
- Barney, J.B. (1991). Firm resource and sustained competitive advantage. *Journal of Management*, 17, 99-120.
- Baron, R.M. and Kenny, D.A. (1986) "The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations", *Journal of Personality and Social Psychology*, 51(6), 1173-1182.
- Bell, M. and Pavitt, K. (1993). Technological accumulation and industrial growth: contrast between development and developing countries. *Industrial and Corporate Change*, 2(2), 157-210
- Black, S.A. and Porter, L.J. (1996). Identification of the critical factors of TQM. *Decision Sciences*, 27 (1), 1-22
- Braga, H. and Willmore, L. (1991). Technological imports and technological effort: An analysis of their determinants in Brazilian firms, *The Journal of Industrial Economics*, 39(4), 421-432
- Burns, T. and Stalker, G.M. (1961). *The Management of Innovation*. Tavistock Publishing: London.
- Cascio, W. F. (1996). Strategic human resource management in high technology industries. In *Organizational Issues in High Technology Management*, edited by L.R. Gómez-Mejía and M.W. Lawless. JAI Press: Greenwich, CT
- Challis, D., Samson, D., and Lawson, B. (2005). Impact of technological, organizational and human resource investments on employee and manufacturing performance: Australian and New Zealand evidence. *International Journal of Production Research*, 43(1), 81-107.
- Chau, P.Y.K. (1997): "Reexamining a Model for Evaluating Information Center Success Using a Structural Equation Modeling Approach", *Decision Sciences*, 28 (2), 309-334.
- Chiesa V., Coughlan P., and Voss C. (1996). Development of a technical innovation audit. *Journal of Product Innovation Management*, 13(2), 105-136.
- Cooms, G. and Rosse, J. (1992). Recruiting and hiring the high-technology professional: trends and future directions. *Advances in Global High-Technology Management*, 1, 91-107.
- Corbett, C. and Wassenhove, L.V. (1993). Trade-offs? What trade-offs? Competence and competitiveness in manufacturing strategy. *California Management Review*, 35(2), 107-122.
- Delbecq, A. and Mills, P. (1985). Managerial practices that enhance innovation. *Organizational Dynamics*, 14(1), 24-34
- Dess, G.C. and Robinson, R.B. (1984). Measuring organizational performance in the absence of objective measures: the case of a privately held firm and conglomerate business unit. *Strategic Management Journal*, 5(3), 265-273.

- 1
2
3 Dow, D., Samson, D. and Ford, S. (1999). Exploding the myth: do all quality management practices
4 contribute to superior quality performance? *Production and Operations Management*, 8(1), 1-27.
- 5
6 European Commission (2003). 2003 European innovation scoreboard: Technical Paper No 4, sectoral
7 innovation scoreboards. *Innovation Directorate of DG Enterprise Innovation/SMEs Programme*,
8 (November).
- 9
10 Flynn, B.B., (1994). The relationship between quality management practices, infrastructure and fast
11 product innovation. *Benchmarking for Quality Management & Technology*, 1(1), 48-64.
- 12
13 Flynn, B.B., Sakakibara, S., and Schroeder, R.G. (1994). A proposed quality management theory and
14 associated measurement instrument. *Journal of Operations Management*, 11, 339-366.
- 15
16 Flynn, B.B., Schroeder, R.G., and Sakakibara, S. (1995). The impact of quality management practices on
17 performance and competitive advantage. *Decision Sciences*, 26(5), 659-692.
- 18
19 Foss, N. (1993). Theories of the firm: contractual and competence perspective. *Journal of Evolutionary*
20 *Economics*, 3(2), 127-144.
- 21
22 Foss, N. (1998). "The competence-based approach: Veblenian ideas in the modern theory of the firm.
23 *Cambridge Journal of Economics*, 22, 479-495.
- 24
25 Freeman, Ch. (1982). "Success and failure in industrial innovation. In *The Economics of Industrial*
26 *Innovation*, 2d ed. MIT Press: Cambridge, MA.
- 27
28 Fry, L.W. and Smith, D.A. (1987). Congruence, contingency, and theory building. *Academy of*
29 *Management Review*, 12, 117-132.
- 30
31 Furukawa, R. and Goto, A. (2006). The role of corporate scientists in innovation. *Research Policy*, 35,
32 24-36.
- 33
34 Gabor, A. (1990): *The Man who Discovered Quality*. Random House: New York.
- 35
36 Galende, J. and Suárez, I. (1999). A resource-based analysis of the factors determining a firm's R&D
37 activities. *Research Policy*, 28, 891-905.
- 38
39 Galende, J. and de la Fuente, J.M. (2003). Internal factor determining a firm's innovative behaviour.
40 *Research Policy*, 32, 715-736.
- 41
42 Garrido, E., Martín-Peña, M.L., and García-Muiña, F. (2007). Structural and infrastructural practices as
43 elements of content operations strategy. The effect on a firm's competitiveness. *International Journal*
44 *of Production Research*, 45(9), 2119-2140.
- 45
46 Gómez-Mejía, L. and Saura, M. (1996). Los sistemas de remuneración basados en el desempeño para el
47 caso de las empresas de alta tecnología. *Revista Europea de Dirección y Economía de la Empresa*, 5,
48 181-196.
- 49
50 Grant, R.M. (1991). The resource-based theory of competitive advantage: implications for strategy
51 formulation. *California Management Review*, 33, 114-135.
- 52
53 Gustafson, D.H., Hundt, A.S. (1995). Findings of innovation research applied to quality management
54 principles for health care. *Health Care Manage Review*, 20(2), 16-33.
- 55
56 Hair, J.F., Anderson, R.E., Tatham, R.E., and Black, W.C. (1999): *Análisis Multivariante*, 5th ed.
57 Prentice Hall: Madrid.
- 58
59 Haner, U.E. (2002). Innovation quality—a conceptual framework. *International Journal of Production*
60 *Economics*, 80, 31-37.

- 1
2
3 Hill, C.W.L. (1988). Differentiation versus low cost or differentiation and low cost: a contingency
4 framework. *Academy of Management Review*, 13(3), 401-412.
- 5
6 Hybels, R.C. and Barley, S.R. (1996). Co-optation and the legitimation of professional identities: human
7 resource policies in high technology firms. In *Organizational Issues in High Technology*
8 *Management*, edited by L.R. Gómez-Mejía and M.W. Lawless, M.W. JAI Press: Greenwich, CT.
- 9
10 Hodgson, G. (1998). Evolutionary and competence-based theories of the firm. *Journal of Economy*
11 *Studies*, 25(1), 25-56.
- 12
13 Hollenstein, H. (1996). A composite indicator of a firm's innovativeness—an empirical analysis based on
14 survey data for Swiss manufacturing. *Research Policy*, 25(4), 633-45.
- 15
16 Imai, M. (1986). *The Key to Japan's Competitive Success*. Random House: New York.
- 17
18 Jaccard, J., Turrisi, R., and Wan, C.K. (1990). Interaction effects in multiple regression. *Sage University*
19 *Paper Series on Quantitative Applications in the Social Sciences*, No. 72. Sage Publications: Newbury
20 Park, CA.
- 21
22 Jones, A.P., James, L.R. (1979). Psychological climate: dimensions and relationships of individual and
23 aggregated work environment perceptions. *Organizational Behaviour and Human Performance*, 23,
24 201-250.
- 25
26 Judd, C.M. and Kenny, D.A. (1981) "Process Analysis: Estimating mediation in treatment evaluations",
27 *Evaluation Review*, 5(5), 602-619.
- 28
29 Kannebley, S., Porto, G.S. and Pazello, E.T. (2005). Characteristics of Brazilian innovative firms: An
30 empirical analysis based on PINTEC-industrial research on technological innovation. *Research*
31 *Policy*, 34, 872-893.
- 32
33 Kaynak, H. (2003). The relationship between total quality management practices and their effects on firm
34 performance. *Journal of Operations Management*, 21(4), 405-435.
- 35
36 Kumar, N. and Saqib, M. (1996) "Firm size, opportunities for adaptation and in-house R&D activity in
37 developing countries: the case of Indian manufacturing", *Research Policy* 25(5), 713-722.
- 38
39 Lau, C. M., y Ngo, H. Y. (2004). The HR system, organizational culture, and product innovation.
40 *International Business Review*, 13(6), 685-703.
- 41
42 Laursen, K. and Foss, N. (2003). New human resource management practices, complementarities and the
43 impact on innovation performance. *Cambridge Journal of Economics*, 27, 243-263.
- 44
45 Lord, F.M. and Novick, M.R. (1968). *Statistical Theories of Mental Test Scores*. Addison-Wesley:
46 Reading, MA.
- 47
48 Maidique, M. and Zirger, B.J. (1984). A study of success and failure in product innovation: the case of
49 the U.S. electronics industry. *IEEE Transactions on Engineering Management*, 31(4), 192-203.
- 50
51 Martínez-Lorente, A.R., Dewhurst, F. and Dale, B.G. (1999). TQM and business innovation. *European*
52 *Journal of Innovation Management*, 2(1), 12-19.
- 53
54 McAdam, R., Armstrong, G., and Kelly, B. (1998). Investigation of the relationship between total quality
55 and innovation: a research study involving small organizations. *European Journal of Innovation*
56 *Management*, 1(3), 133-147.
- 57
58 Nowak, A. (1997). Strategic relationship between quality management and product innovation. *The Mid-*
59 *Atlantic Journal of Business*, 33(2), 119-135.
- 60

- 1
2
3 Nunnally, J. (1978): *Psychometric Theory*, 2d ed. McGraw-Hill: New York.
- 4 Pannirselvan, G.P., Ferguson, L., Ash, R.C. and Siferd, S. (1999). Operations management research: an
5 update for the 1990s. *Journal of Operations Management*, 18, 95-112.
- 6
7 Perdomo-Ortiz J., González-Benito J., and Galende J. (2006). Total Quality Management as a forerunner
8 of Business Innovation Capability. *Technovation*, 26, 1170-1185.
- 9
10 Peteraf, M.A. (1993). The cornerstones of competitive advantage: a resource-based view. *Strategic*
11 *Management Journal*, 14(3), 179-1991.
- 12
13 Porter, M. (1985). *Competitive Advantage*. The Free Press: New York.
- 14
15 Powell, T.C. (1995). Total Quality Management as competitive advantage: a review and empirical study.
16 *Strategic Management Journal*, 16(1), 15-38.
- 17
18 Prajogo, D.I., and Sohal, A.S. (2001). TQM and innovation: a literature review and research framework.
19 *Technovation*, 21(9), 539-558.
- 20
21 Prajogo, D.I., and Sohal, A.S. (2003). The relationship between TQM practices, quality performance, and
22 innovation performance—an empirical examination. *International Journal of Quality and Reliability*
23 *Management*, 20(8), 901-918.
- 24
25 Prajogo, D.I., and Sohal, A. S. (2004). The multidimensionality of TQM practices in determining quality
26 and innovation performance—an empirical examination. *Technovation*, 24(6), 443-515.
- 27
28 Prescott, J.E. (1986). Environment as a moderator of strategic performance relationship. *Academy of*
29 *Management Journal*, 29, 329-346.
- 30
31 Rahman, S. and Bullock, P. (2005). “Soft TQM, hard TQM, and organisational performance
32 relationships: an empirical investigation. *OMEGA: The International Journal of Management Science*,
33 33, 73-83.
- 34
35 Rumelt, R.P. (1984). Toward a strategic theory of the firm. In *Competitive Strategic Management*, edited
36 by R. Lamb. Prentice-Hall: New York, 556-570.
- 37
38 Samson, D. and Terziovski, M. (1999). The relationship between total quality management practices and
39 operational performance. *Journal of Operations Management*, 17(4), 393-409.
- 40
41 Saraph, J., Benson, G. and Schroeder, R. (1989). An instrument for measuring the critical factors of
42 quality management. *Decision Sciences*, 20(4), 457-478.
- 43
44 Schroeder, R.G., Scudder, G.D. and Elm, D.R. (1989). Innovation in manufacturing. *Journal of*
45 *Operations Management*, 8(1), 1-15.
- 46
47 Singh, P.J., and Smith, A.J.R. (2003). Relationship between TQM and innovation: an empirical study.
48 *Journal of Manufacturing Technology Management*, 15 (May), 394-401.
- 49
50 Sitkin, S.B., Sutcliffe, K.M. and Schroeder, R.G., (1994). Distinguishing control from learning in Total
51 Quality Management: a contingency perspective. *Academy of Management Review*, 19(3), 537-564.
- 52
53 Sousa, R. and Voss, C. (2002). Quality management re-visited: a reflective review and agenda for future
54 research. *Journal of Operations Management*, 20(1), 91-109.
- 55
56 Subramanian A. and Nilakanta S. (1996). Organizational innovativeness: exploring the relationship
57 between organizational determinants of innovation, types of innovations and measures of
58 organizational performance. *OMEGA*, 24(6), 631-647.
- 59
60 Tang, H. K. (1999). An inventory of organizational innovativeness. *Technovation*, 19, 41-51.

- 1
2
3 Teece, D., Pisano, G., and Shuen, A. (1997). Dynamic capabilities and strategic management. *Strategic*
4 *Management Journal*, 18(7), 509 -533.
- 5
6 Terziovski, M. and Samson, D. (1998). The link between total quality management practice and
7 organizational performance. *International Journal of Quality and Reliability Management*, 16(3), 226-
8 237.
- 9
10 Tidd J., Driver C., and Saunders P. (1996). Linking technological, market and financial indicators of
11 innovation. *Economics of Innovation and New Technology*, 4, 155-172.
- 12
13 Tidd, J., Bessant, J. and Pavitt, K. (1997). *Managing Innovation: Integrating Technological, Market and*
14 *Organizational Change*. John Wiley & Sons: New York.
- 15
16 Utterback, J. (1971). The process of technological innovation within the firm. *Academy of Management*
17 *Journal*, 14, 75-88.
- 18
19 Van de Ven, A.H. and Drazin, R. (1985). The concept of fit in contingency theory. In *Research in*
20 *Organizational Behaviour*, Vol. 7, edited by L.L. Cummings and B.M. Staw JAI Press: Greenwich,
21 CT, 333-365.
- 22
23 Venkatraman, N. (1989). The concept of fit in strategy research: toward verbal and statistical
24 correspondence. *Academy of Management Review*, 14(3), 423-444.
- 25
26 Wang, C.L. and Ahmed, P.K. (2002). Learning through quality and innovation. *Managerial Auditing*
27 *Journal*, 17(7), 417-423.
- 28
29 Wheelwright, S.C. (1984). Reflecting corporate strategy in manufacturing decisions. *Business Horizons*,
30 21(1), 57-66.
- 31
32 Zollo, M., and Winter, S. (2002). Deliberate learning and the evolution of dynamic capabilities.
33 *Organization Science*, 13(3), 339 – 351.
- 34
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Table 1: Evaluation of the TQM measurement instrument

	Mean (S.D.)	Cronbach's α	Factor Loadings	% Variance Explained
Management support (TQM1)		0.7718		60.1503
Q11 Definition of a quality strategy	5.76 (1.22)		0.851	
Q12 Involvement of management with quality	5.57 (1.49)		0.752	
Q13 Fixing of long- and medium-term earnings	5.07 (1.62)		0.593	
Q14 Existence of guidelines on quality	5.25 (1.34)		0.874	
Information for quality (TQM2)		0.7512		66.8412
Q21 Information available for employees	4.97 (1.65)		0.856	
Q22 Use of statistical techniques for quality control	4.41 (1.69)		0.810	
Q23 Periodical evaluations of work quality	3.82 (1.76)		0.785	
Process Management (TQM3)		0.7986		62.4267
Q31 Documenting production processes	5.42 (1.31)		0.782	
Q32 Process design with problem identification	5.03 (1.20)		0.836	
Q33 Orderly and clean work areas	5.35 (1.33)		0.744	
Q34 Emphasis on preventive maintenance	5.08 (1.33)		0.797	
Product Design (TQM4)		0.6420		49.1516
Q41 Quality over cost in product design	4.94 (1.47)		0.478	
Q42 Product design to customers' requirements	6.33 (0.77)		0.735	
Q43 Functional and supplier integration in product design	5.49 (1.13)		0.728	
Q44 Technical reliability tests before commercialization	5.79 (1.33)		0.817	
Human Resource Management (TQM5)		0.6668		50.4416
Q51 Creation of problem-solving teams	5.25 (1.43)		0.789	
Q52 Training of personnel in matters of quality and teamwork	4.75 (1.50)		0.788	
Q53 Incentive systems based on quality	3.32 (1.94)		0.640	
Q54 Selection of personnel based on criteria of work competence	4.60 (1.51)		0.605	
Q55 Similar or undifferentiated services for all employees (*)				
Relationship with Suppliers and Customers (TQM6)		0.6317		73.0834
Q61 Long term relationships of trust with suppliers	5.74 (0.97)		0.855	
Q62 Information from customers and suppliers for product improvement	5.59 (1.02)		0.855	
Q63 Quality over price in the selection of suppliers (*)				
Q64 Few suppliers to ensure supply (*)				

(*) Eliminated items.

Table 2: Evaluation of the BIC measurement instrument

	Mean (S.D.)	Cronbach's α	Factor Loadings	% Variance Explained
Planning and Commitment of the Management (BIC1)				
I11	Definition of a technological innovation strategy	4.81 (1.44)	0.862	74.3001
I12	Specific budget for innovative ideas	4.13 (1.74)	0.862	
I13	There is still a lot to learn in day to day work (*)			
Behaviour and Integration (BIC2)				
I21	There are benefits to be had from project failure and error	5.02 (1.62)	0.596	49.2509
I22	Permanent interest in others' work	3.82 (1.45)	0.745	
I23	Exchange of information and knowledge among work groups	4.87 (1.34)	0.596	
I24	Several people take the initiative in new projects	4.21 (1.52)	0.840	
Projects (BIC3)				
I31	Formulation of innovative projects	5.27 (1.32)	0.746	55.7166
I32	Projects with suitable programming and resources	4.88 (1.26)	0.784	
I33	Projects help to reduce the risk of innovation	5.18 (1.04)	0.810	
I34	Evaluation of technical, economic and commercial feasibility of ideas	5.05 (1.37)	0.633	
Knowledge and Skills (BIC4)				
I41	Own knowledge is generated (R+D)	5.20 (1.41)	0.806	63.7324
I42	Knowledge protection systems	4.48 (1.44)	0.856	
I43	Periodical evaluations of practices and routines	4.36 (1.61)	0.728	
I44	Processes require skills that are difficult to acquire (*)			
Information and Communication (BIC5)				
I51	Permanent Information Flow	4.66 (1.33)	0.835	63.8316
I52	Management of Documentation and Information	5.42 (1.22)	0.823	
I53	Information system as a stimulus for new ideas	4.28 (1.36)	0.821	
I54	Supervision system and technology transfer	4.39 (1.40)	0.713	
External environment (BIC6)				
I61	Innovation projects in cooperation	4.15 (1.77)	0.806	62.3025
I62	Relationship with centers or universities	4.15 (1.92)	0.803	
I63	Technological comparison with the competition	4.95 (1.61)	0.822	
I64	Participation in federations, Chambers or associations	4.88 (1.48)	0.724	

(*) Eliminated items.

Table 3: Measurement scale of technological innovation

	Mean (S.D.)	Cronbach's α	Factor Loadings	% Variance Explained
Technological Innovation		0.7583		58.4570
T11 Range of products and launch rhythm	3.23 (0.91)		0.593	
T12 Technical novelty in production systems	3.40 (0.88)		0.753	
T13 Expenditure on technological innovation	3.24 (1.02)		0.887	
T14 Generation of patents	2.85 (1.04)		0.795	

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Table 4: Regression analysis between technological innovation and TQM

	Technological Innovation						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Constant (β)	2.593*** (.367)	3.145*** (.244)	2.758*** (.379)	2.417*** (.506)	2.600*** (.295)	3.035*** (.492)	2.600*** (.295)
TQM1: Management support	.109 (.067)	--	--	--	--	--	ns
TQM2: Information for quality	--	.008 (.063)	--	--	--	--	ns
TQM3: Process management	--	--	.081 (.071)	--	--	--	ns
TQM4: Product design	--	--	--	.135 (.089)	--	--	ns
TQM5: Human Resource Management	--	--	--	--	.129** (0.064)	--	.129** (.064)
TQM6: Relations with agents	--	--	--	--	--	.026 (.086)	ns
R2	0.026	.000	.013	.023	.039	.001	.039
F	2.665	.023	1.290	2.325	4.124**	.089	4.124**

*** Coefficient significant at 1%.

** Coefficient significant at 5%.

* Coefficient significant at 10%.

Notes: Typical errors between parentheses; ns = not significant.

Table 5: Moderated regression analysis between technological innovation and TQM

Independent Variables	Constant	β Coefficients			R ²	F	ΔF
TQM3: Process management	2.758***	0.081			0.013	1.290	
TQM3, BIC1: Plan. &management commitment	2.530***	-0.014	0.162***		0.087	4.778***	8.175***
TQM3, BIC1, TQM3xBIC1	0.842	0.342	0.597**	-0.088*	0.116	4.325***	3.208*
TQM3: Process management	2.758***	0.081			0.013	1.290	
TQM3, BIC3: Projects	2.269***	-0.028	0.207**		0.058	3.086**	4.834**
TQM3, BIC3, TQM3xBIC3	-0.899	0.636	0.881***	-0.137**	0.099	3.617**	4.463**
TQM3: Process management	2.758***	0.081			0.013	1.290	
TQM3, BIC4: Knowledge & skills	2.431***	-0.055	0.222***		0.105	5.888***	10.367***
TQM3, BIC4, TQM3xBIC4	0.633	0.317	0.630**	-0.082*	0.131	4.978***	2.931*
TQM3: Process management	2.758***	0.081			0.013	1.290	
TQM3, BIC6: External environment	2.563***	0.022	0.111*		0.047	2.472*	3.621*
TQM3, BIC6, TQM3xBIC6	0.655	0.409*	0.576**	-0.092*	0.079	2.817**	3.3387*

Dependent Variable: Technological Innovation

*** Coefficient significant at 1%.

** Coefficient significant at 5%.

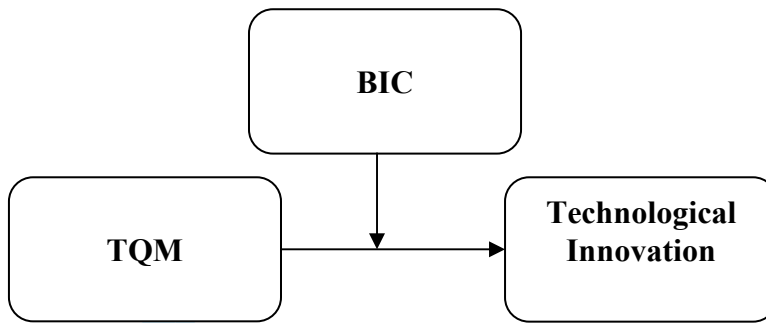
* Coefficient significant at 10%.

Table 6: Measurement of overall fit of the alternative models and saturated model

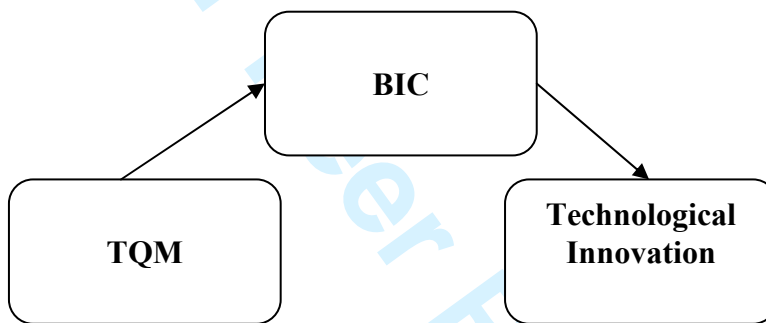
Mediating variable	χ^2	$\chi^2/d.f.$	RMSR	GFI	AGFI	TLI	CFI	TQM ₅ → BIC _j	BIC _j → Tec Innov
	(p)	rv: ≤ 3	rv: ≤ 0.10	rv: ≥ 0.90	rv: ≥ 0.80	rv: ≥ 0.90	rv: ≥ 0.90		
BIC ₁	30.672 (.584)	.929	.000	.944	.906	1.014	1.000	.71***	.37**
BIC ₂	78.750 (.010)	1.514	.071	.889	.833	.879	.905	.80***	.32**
BIC ₃	55.322 (.350)	1.064	.025	.920	.879	.986	.989	.72***	.33**
BIC ₄	51.503 (.149)	1.226	.047	.917	.870	.956	.967	.74***	.37**
BIC ₅	62.213 (.157)	1.196	.044	.911	.866	.963	.971	.82***	.27**
BIC ₆	85.722 (.002)	1.649	.079	.884	.827	.876	.903	.60***	.30**

Notes: rv: recommended value (based on Chau, 1997); coefficients in bold fit the recommended values
 *** p < .01; ** p < .05; * p < .10

Figure 1: Contingency relationships between TQM and technological innovation



BIC moderates the TQM–technological innovation relationship



BIC mediates the TQM–technological innovation relationship

Figure 2: Structural equation modelling of BIC₃ as mediator of the relationship between TQM₅ and technological innovation

