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Six Sigma, absorptive capacity and organizational learning orientation

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Abstract

The importance of the Six Sigma methodology in industry is growing constantly. However, there are few empirical studies that analyze the advantages of this methodology and its positive effects on organizational performance. The purpose of this paper is to extend understanding of the success of Six Sigma quality management initiatives by investigating the effects of Six Sigma teamwork and process management on absorptive capacity. It also seeks to understand the relation between absorptive capacity and organizational learning as two sources of sustainable competitive advantage. The information used comes from a larger study, the data for which were collected from a random sample of 237 European firms. Of these 237 organizations, 58 are Six Sigma organizations. Structural Equation Modelling (SEM) was used to test the hypotheses. The main findings show that Six Sigma teamwork and process management positively affect the development of absorptive capacity. A positive and significant relationship is also observed between absorptive capacity and organizational learning orientation. The findings of this study justify Six Sigma implementation in firms. This study provides us with an in-depth understanding of some structural elements that characterize the Six Sigma methodology, enabling us to provide an explanation for its success.

Keywords

Six Sigma, teamwork, process management, absorptive capacity, organizational learning orientation.

1. Introduction

Quality management has entered a phase of maturity with conceptual foundations and definitions (Sousa and Voss, 2002). However, new initiatives for quality management continue to appear. One example is the Six Sigma methodology. The Six Sigma methodology is becoming one of the most successful quality management initiatives. Motorola and General Electric provide the best-known examples of Six Sigma success. The former obtained savings of over 940 million dollars in three years (Hann et al., 1999), and the latter increased its operating margin from 14.4% to 18.4% during the first five years of program implementation (Lucier et al., 2001). Shamji (2005) studied several firm experiences, including those of Samsung Electronics, American Express and DuPont and observed that the savings related to each Six Sigma improvement project ranged from 100,000 to 200,000 dollars. The positive effects of Six Sigma implementation are well known due to experiences like Motorola's, General Electric's, and Allied Signal's, but the literature contains little empirical research that tests Six Sigma's influence on organizational performance. Lee and Choi (2006) observed Six Sigma's positive effects on quality improvement, process innovation, and corporate

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competitiveness. Antony et al. (2007) and Antony et al. (2005) studied Six Sigma implementation in UK service and manufacturing SMEs, respectively. The results showed benefits such as improved customer satisfaction, reduction in process variability, increased profitability and increased market share. However, not all results are favourable for Six Sigma. For example, Goh et al. (2003) studied stock price performance on the Six Sigma announcement day. They could not find significant differences in stock price performance on the announcement day or in the long run. They justified these results by arguing that Six Sigma has a weak impact on stock performance. This paper contributes to the empirical literature on Six Sigma by observing its positive effects on organizational performance, through the observation of absorptive capacity and organizational learning orientation. Specifically, our study finds that teamwork and process management are important Six Sigma practices and tests whether they could be a reason for the initiative’s success.

Recently, Schroeder et al. (2008) published a theoretical analysis of Six Sigma methodology. In this study, Schroeder et al. (2008) identify research issues for future study. One of these issues is based on the fact that “Six Sigma is an organizational learning process and one that results in greater knowledge” (Schroeder et al., 2008, p.549). As a consequence, “viewing Six Sigma through the lens of knowledge management and organizational learning can lead to insights about how to create, retain, and diffuse knowledge using a structured method” (Choo et al., 2007; Lapré et al., 2000). Other recent studies have indicated the importance of pursuing this issue in the study of Six Sigma. For example, Linderman et al. (2003; 2006) argue that it would be interesting to consider Six Sigma from the perspective of knowledge management. Lloréns et al. (2006) propose studying how Six Sigma practices create a good learning climate. Choo et al. (2007) indicate the lack of studies that analyze how the technical and social components of QM practices, and specifically those of Six Sigma, lead to learning and knowledge creation. We therefore orient our study to all of these proposed lines of research and attempt to study the effects of the Six Sigma methodology on knowledge absorptive capacity and its effect on organizational learning orientation.

Organizational learning constitutes one of the sources of competitive advantage for organizations (Huber, 1996; Rindova and Fombrun, 1999; Senge, 1990; Tu et al., 2006). Positive effects of learning orientation on organizational performance have been tested (Calantone et al., 2002; Tien and Hsin, 2005; Zahra et al., 2000). Absorptive capacity plays a crucial role in the search for knowledge. As a result, absorptive capacity has been one of the most studied aspects of knowledge management in recent years (Fosfuri and Tribó, 2008; Jansen et al., 2005; Lane et al., 2006; Lichtenthaler, 2009; Todorova and Durisin, 2007; Tu et al., 2006). “Absorptive capacity is one of the constructs to emerge in organizational research in recent decades” (Lane et al., 2006, p.833). The current turbulent dynamic environments have made absorptive capacity one of the most important dynamic capacities in generating sustainable competitive advantage (Fosfuri and Tribó, 2008; Lenox and King, 2004; Tu et al., 2006; Zahra and George, 2002). Our study seeks to enrich this line of research by observing whether we can go beyond our knowledge that teamwork and process management of the Six Sigma methodology affect absorptive capacity to determine whether absorptive capacity can be related to organizational learning orientation.

The main purpose of this paper is to determine whether Six Sigma teamwork and process management have a positive influence on the development of absorptive capacity. We will then determine whether this absorptive capacity is related to organizational learning orientation. The paper is structured as follows: After this introduction, we present a literature review that covers three areas: Six Sigma methodology and its teamwork and process management; the importance of absorptive capacity in the organization; and the relationships between teamwork and process management in Six Sigma and absorptive capacity, and the relationship between absorptive capacity and organizational learning orientation in Six Sigma firms. After we review the literature, we describe the methodology and the analysis performed. Subsequently, we discuss the results obtained and present the main conclusions, limitations and recommended directions for future research.

2. Theoretical background

2.1. The Six Sigma Methodology: Teamwork and Process Management

Six Sigma is defined as "an organized, parallel-meso structure to reduce variation in organizational processes by using improvement specialists, a structured method, and performance metrics with the aim of achieving strategic objectives" (Schroeder et al., 2008, p.540). Six Sigma is a method for improving organizational processes that goes beyond quality assurance or quality control (Harry, 2000). In fact, based on the literature review and considering Six Sigma as a management philosophy, this methodology is similar to the concept of Total Quality Management (TQM) (Cheng 2009; Green, 2006; Lloréns et al., 2006; Lucas, 2002; Van Iwaarden et al., 2008).

Teamwork is one of the pillars of Six Sigma methodology (Breyfogle, 2003; Lloréns et al., 2006; Lowenthal, 2002; Pande et al., 2002). Continuous improvement proposed by this philosophy is developed through different projects assigned to teams of workers. The success of improvement projects depends on these cross-functional teams (Pande et al., 2002; Shamji, 2005). Teamwork is the key factor for Six Sigma success, due to the fact that team members are the main carriers of the new philosophy (Thawani, 2004). In one year, General Electric invested $450 million in six improvement projects, obtaining benefits near $1.2 billion (Lucas, 2002). Shamji (2005) collected several firm experiences including those of Samsung Electronics, American Express and DuPont and found that the savings derived from each Six Sigma improvement project ranged from $100,000 to $200,000.

The main difference between Six Sigma teamwork and the teamwork in other quality management initiatives is that Six Sigma creates specialized positions, carried by employees, to run its projects instead of overloading the firm's managers (Lloréns et al., 2006). These specialized positions constitute a structure of roles that is one of Six Sigma distinguishing aspects (Zu et al., 2008). Positions such as "Champions", "Master Black Belts", "Black Belts" and "Green Belts" are explicitly established (Sinha and Van de Ven, 2005). According to Gitlow (2005) and Pande et al. (2002), "Champions" are usually members of the Executive Committee. They facilitate the obtaining of resources and elimination of barriers for the development of improvement projects. "Champions" usually sponsor these specific projects. "Master Black Belts" play a role as Six Sigma process leaders, linking top management to the main person responsible for an improvement project. They have developed important abilities and possess deep knowledge of Six Sigma methodology. "Black Belts" are full-time agents dedicated to an improvement project. They are posted to specific projects to be in charge of such activities as putting the project into action, training members, and providing leadership.

“Green Belts” are workers who belong to an improvement project or lead a team but have only part-time dedication to this task.

On the other hand, Six Sigma is clearly oriented to strategic process improvement (Linderman et al., 2003; Schroeder et al., 2008; Zu et al., 2008). Six Sigma practitioners “identify and clarify the core processes whose improvement will yield the most dramatic changes and benefits for customers and the organization” (Lloréns et al., 2006, p.487). Process management orientation to continuous improvement requires that Six Sigma members are trained intensely in abilities, group dynamics and statistical methods and tools (Gitlow, 2005; Lee et al., 2006; Ravichandran, 2006; Zu et al., 2008). For example, the DMAIC cycle (define, measure, analyze, improve and control) is also present in Six Sigma, as a tool for process improvement (Kanji, 2008; Kaushik and Khanduja, 2009; Schroeder et al., 2008). Besides, Breyfogle (2003) describes a very wide variety of statistical tools that can be used in each phase of the DMAIC cycle. Examples of these tools include scorecards, Pareto diagrams, cause-effect diagrams, benchmarking, brainstorming, histograms, quality function deployment (QFD), control charts, comparison tests, regression analysis and many others. Kanji (2008) adds other known practices that Six Sigma can incorporate, such as Poka-Yoke, Kaizen, Kanban and Lean Manufacturing. Thus, when positions and roles have been assigned and tools and abilities developed, teams begin the work that focuses on defect rate reduction in each improvement project selected. Teams design successful solutions and show that the tools and abilities learned work well (Cooper, 2003).

In this way, Six Sigma process management requires very solid statistical methodologies of experimentation and research (De Mast, 2006; Kanji, 2008). Lloréns et al. (2006) present Six Sigma as the strongest technique for quality improvement from the statistical perspective. In fact, the definition given by Linderman et al. (2003) indicates how this initiative describes a process management that is grounded in statistical methods. Thus, it can be concluded that the Six Sigma method for process improvement requires an intensive training of the full-time specialists, and the full integration of statistical and non-statistical tools, which are unique (Schroeder et al., 2008). Therefore, another distinctive aspect of the Six Sigma methodology, in addition to teamwork, is the importance given to process management.

2.2. Absorptive capacity

The most cited definition in the literature on knowledge absorptive capacity was developed by Cohen and Levinthal (1990). For them, absorptive capacity consists of “the ability of a firm to recognize new, external, information, assimilate it, and apply it to commercial ends” (Cohen and Levinthal, 1990, p.128). An alternative definition by Lane et al. (2006) starts from an in-depth study of the most important research contributions related to absorptive capacity and attempts to revitalize the construct and eliminate possible deviations from its real significance. Thus, these authors state that “absorptive capacity is a firm’s ability to utilize externally held knowledge through three sequential processes: (1) recognizing and understanding potentially valuable new knowledge outside the firm through exploratory learning, (2) assimilating valuable new knowledge through transformative learning, and (3) using the assimilated knowledge to create new knowledge and commercial outputs through exploitative learning” (Lane et al., 2006; p.856). As Tu et al. (2006) indicate, both definitions show a clear orientation to external knowledge and information. However, “implicit in the definition is the notion that firms are aware of internal information and have access to it" (Tu et al., 2006, p.694).

There are different approaches to the phases of the knowledge absorption process (Cohen and Levinthal, 1990; Szulanski, 1996; Lane et al., 2001; Liao et al., 2003; Van den Bosch et al., 1999). Our study chooses the classification developed by Zahra and George (2002), as this seems to be the most accepted, having been used subsequently by Malhotra et al. (2005) and Lane et al. (2006). Zahra and George (2002) divide the process of knowledge absorption into four dimensions: *acquisition* of general external knowledge, (2) *assimilation*, analysis and comprehension of the information obtained from external sources, (3) *transformation*, which combines existing and the new, acquired and assimilated knowledge, and (4) *exploitation*, which is based on routines that facilitate improvement, expansion, and influence on existing capacities or the creation of new ones, thanks to the knowledge acquired and transformed.

2.3. Six Sigma teamwork, process management and absorptive capacity

We will now analyze how teamwork and process management included in Six Sigma methodology can affect absorptive capacity, through four arguments. Firstly, various studies have remarked that using mechanisms to integrate workers has a positive effect on absorptive capacity (Cohen and Levinthal, 1990; Lane et al., 2006; Todorova and Durisin, 2007; Van den Bosch et al., 1999; Zahra and George, 2002). Jansen et al. (2005) study whether cross-functional interfaces, such as teamwork, are positively related to the four dimensions of absorptive capacity identified by Zahra and George (2002). Jansen et al. (2005) affirm that systems such as teams use lateral communications mechanisms, which facilitate knowledge flow through functional borders, enabling connection between different sources and increasing the interaction between areas. This enhanced communication should contribute to the first two phases, that of knowledge acquisition and assimilation. Further, these interfaces permit employees to combine existing and recently acquired knowledge. According to authors like Cohen and Levinthal (1990) and Daft and Lengel (1986), cross-functional interfaces help to integrate the different bodies of knowledge and to create routines within the units. These aspects will contribute to the transformation and exploitation of knowledge, the last two phases in absorptive capacity. Results show a positive relation between cross-functional interfaces and the four phases proposed by Zahra and George (2002), although this relationship is only significant in the case of the first three.

The QM literature has shown how Quality Management teamwork encourages workers to share expert knowledge related to their immediate work tasks and to use their creative abilities to suggest new ways to improve (Cole et al., 1993; Chiles and Choi, 2000; Silos, 1999), a clear example of the kind of team Jansen et al. (2005) observed. As stated above, teamwork constitutes one of the main aspects of Six Sigma methodology (Breyfogle, 2003; Lloréns et al., 2006; Lowenthal, 2002; Pande et al., 2002). Six Sigma attempts to decrease the number of defects that appear in different organizational processes and to use cross-functional teams who, through communication mechanisms, strengthen the relationship between different areas of functioning and stimulate knowledge absorption. For example, Park et al. (2009) argue that the activities performed by Six Sigma teams enable the creation and capturing of information, the storing and sharing of information, and the use of information in the DMAIC cycle. Thus, Six Sigma teamwork has a series of characteristics in common with the teams studied by Jansen et al. (2005), characteristics that affect absorptive capacity positively.

Secondly, Six Sigma teamwork is distinguished by the creation of specialized positions (Lloréns et al., 2006; Zu et al., 2008). Those who hold positions such as “Champion”, “Master Black Belt”, and “Black Belt” play the role of leaders (Choo et al., 2007), creating recognition of the need and fostering the collective desire to learn (Senge 1999, p.38, in Choo et al., 2007), thus guiding the learning efforts (Choo et al., 2007; Wiklund and Wiklund, 2002). Through the formation and creation of these specialized positions, Six Sigma permits the development and better use of existing knowledge in the organization (DeMast, 2006). Leadership should promote the most beneficial learning by indicating how efforts to absorb knowledge should be conducted and by playing a helpful role in facilitating these efforts. Leadership should guide and direct the efforts to absorb knowledge and can constitute an important aid in achieving this absorption, yielding advantageous learning as a result.

Further, in Six Sigma, people who hold these specialized positions have all the time they need to spend on the Six Sigma projects and thus are a very important resource devoted to problem solving (Choo et al., 2007). Knowledge absorption plays a key role in problem solving. The availability of human resources dedicated to problem solving, among other tasks, has a very positive effect, since as Choo et al. (2007) argue, the availability of resources constitutes a crucial antecedent for achieving knowledge creation and learning.

Thirdly, as Gupta and Govindarajan (2000) argue, another important antecedent of absorptive capacity is the degree of similarity between the work units in matters of language, culture, etc. These authors study what they call “homophily”, which they define as “the degree to which two or more individuals who interact are similar in certain attributes” (Rogers, 1995, pp.18-19). Sharing beliefs, language and even personal characteristics facilitates communication and thus the absorption of new knowledge. On observing this issue in Six Sigma, Gutierrez et al. (2009) conducted a study in which they demonstrate empirically that Six Sigma teamwork facilitates the development of a shared vision among team members. Shared vision facilitates a greater similarity between the receiving and the sending unit, achieving the “homophily” proposed by Gupta and Govindarajan (2000), thus having positive repercussions for absorptive capacity.

Finally, Linderman et al. (2003; 2006) argue that the fact that Six Sigma teams, following the method’s goal-theoretical perspective, pursue specific and challenging goals for improvement, which have positive effects on the members’ motivations. According to Locke and Latham (1990), the goal-theoretical perspective affirms that establishing specific and challenging goals leads firms to obtain better results. Therefore, goals should fulfil both requirements. Firstly, establishing specific goals focuses workers’ attention and directs their efforts in the right direction. If goals are specific and clear and do not depend on the worker’s evaluation of them, as in the case of “do the best as you can,” performance improves (Locke and Latham, 1990). Following Lyles and Salk (1996), Lane et al. (2001) indicate that establishing specific objectives enables workers to focus attention on potentially useful knowledge (Huber, 1991; Nonaka, 1994), which affects absorptive capacity positively. The second requirement established by the goal-theoretical perspective is that goals must be challenging and difficult. Such goals increase worker effort and the results obtained (Locke and Latham, 1990; Tubbs, 1986). If we translate this idea to our study, Linderman et al. (2003; 2006) argue that Six Sigma methodology based on specific and challenging goals focuses workers' attention and motivates them to learn and to create knowledge in order to improve, meaning that they should simultaneously develop the ability to absorb knowledge.

According to the arguments explained above, we propose the following hypothesis:

H1: Teamwork implemented in the Six Sigma methodology positively affects absorptive capacity.

Next, we will examine the relationship between processes management and absorptive capacity. Knowledge creation in Six Sigma occurs through the learning generated by the formal processes of improvement (Linderman et al., 2003). Six Sigma process management seeks to detect and correct errors, stimulating absorption of knowledge about processes. Choo et al. (2007) argue that knowledge can be created through problem solving in a programmable way, for example, in a consistent language or a sequence of steps and a set of tools. Thus, the use of structured procedures and techniques as well as tools associated with Six Sigma process management facilitates knowledge acquisition (Choo et al., 2007; Zu et al., 2008). Choo et al. (2007) identify three methodological elements that affect knowledge creation in Six Sigma: employing common metrics, adhering to a stepwise problem solving approach and analyzing with a set of tools.

In general, the methodological elements proposed by Choo et al. (2007) are in line with the approach of Gupta and Govindarajan (2000) discussed above. The existence of the common language, goals and/or shared tools, etc. facilitates knowledge absorption. In pursuing its specific goals, process management in Six Sigma is characterized by the common use of statistical tools by the workers (DFSS; DMAIC cycle, DPMO; scorecards, Pareto diagrams, cause-effect diagrams, benchmarking, brainstorming, histograms, quality function deployment (QFD), control charts, comparison tests, regression analysis, etc.). This approach facilitates communication between workers and contributes to developing a shared language. According to DeMast (2006), Six Sigma's use of shared measures and indicators throughout the organization permits knowledge creation and better use of existing knowledge in the organization, facilitating the integration and coordination of processes. Focusing on common measures of performance means that companies receive knowledge about these processes (Wiklund et al., 2002). Thus, the methodological elements proposed by Choo et al. (2007) stimulate the development of frequent communication, which in turn increases the amount of information available. Further, these elements allow existing efforts to be coordinated and aligned, individual perspectives to be integrated and problems to be better understood. All of this makes it easier for members of the organization to absorb new knowledge.

We also wish to mention the importance of one characteristic of process management. Regarding the stages of acquisition and transformation of absorptive capacity, we find that management of processes acts as a source of information about the processes on which employees work (Flynn et al., 1995; Saraph et al., 1989). Thus, one of the most important factors influencing the success of the absorption process is the existence of prior knowledge related to the new knowledge that will be absorbed (Cohen and Levinthal, 1990; Gupta and Govindarajan, 2000; Todorova and Durisin, 2007; Tu et al., 2006; Van den Bosch et al., 1999; Zahra and George, 2002). This knowledge facilitates learning, as memory helps to establish relationships between new and existing concepts. Knowledge of the process is one of the requirements proposed by Oakland (1989) for achieving continuous improvement in QM. To satisfy this requirement, managing processes and controlling them statistically generates and stores information on the functioning of organizational processes in order subsequently to improve them (Mason and Antony, 2001; Rungtusanatham et al., 1997). Such management drives the phase of knowledge transformation by developing routines that aid in two ways. First, these routines allow better absorption of the new knowledge proceeding from sources. Second, they facilitate combination of the knowledge from these processes and from other sources—such as clients, providers or the competition—with the new knowledge already acquired and assimilated. Throughout Six Sigma's entire structure of process management, discussed above (Choo et al., 2007; Linderman et al., 2003), the methodology provides for the storing of information on the processes studied. Following the methodology thus generates prior knowledge that acts as a facilitator of absorptive capacity (Cohen and Levinthal, 1990; Gupta and Govindarajan, 2000; Van den Bosch et al., 1999; Zahra and George, 2002). According to the foregoing, we establish the following hypothesis:

H2: Process Management implemented in the Six Sigma methodology positively affects absorptive capacity.

2.4. Absorptive capacity and organizational learning orientation in Six Sigma

Organizational learning orientation is defined as the "organization-wide activity of creating and using knowledge to enhance competitive advantage" (Calantone et al., 2002; p.516). Absorptive capacity plays an important role in learning (Cohen and Levinthal, 1990; Lane et al., 2001; 2006; Lyles and Salk, 1996; Tu et al., 2006). Cohen and Levinthal (1990) affirm that the ability to learn in the organization depends on the absorptive capacity of the organization's members. Absorptive capacity represents a unit's capacity to learn (Tsai, 2001). It is an integral part of learning process (Fosfuri and Tribó, 2008). Learning will depend on an organization's ability to recognize valuable new knowledge, assimilate it, and use it for commercial ends (Cohen and Levinthal, 1990). In greater detail, Lichtenthaler (2009) explains that exploratory learning involves knowledge acquisition (Lane et al., 2006) and corresponds to the notion of potential absorptive capacity (Zahra and George, 2002), whereas exploitative learning relates to knowledge assimilation and exploitation (Lane et al., 2006; Lichtenthaler, 2009; Todorova and Durisin, 2007), reflecting the concept of realized absorptive capacity (Zahra and George, 2002). According to Kim (1998), organizational learning is a function of an organization's absorptive capacity. In this study, the author observed how Hyundai Motor Company developed a strategy in developing absorptive capacity of trying to improve the learning orientation. Schilling (2002, p.390) affirmed that "if firms want to be learning oriented, investing in learning creates absorptive capacity and thereby improves the rate at which the firm can learn". Further, in terms of prior knowledge and familiarity with new knowledge, Lane et al. (2006) affirm that absorptive capacity results in assimilation of sought-after knowledge. Thus, we establish the next hypothesis:

H3: Organizational learning orientation is positively related with absorptive capacity.

3. Research method

3.1. Data sample

The sample used to contrast the hypotheses proposed is formed of manufacturing firms and services in the European Union. The firms contacted were chosen randomly from the Amadeus database and the publication *Actualidad Económica* (2004). The procedure for data collection consisted of sending a letter by email explaining the research project to different European firms. The card was addressed to the person responsible for quality management in the firm and explained the reasons for and objectives of the research. It included a direct link to a questionnaire available on Internet. From this link the questionnaire could be accessed, filled out online and, once finished, sent automatically, keeping the responding person anonymity.

The questionnaire was developed after an extensive review of the literature related to quality management practices, absorptive capacity and learning orientation. Once designed, the questionnaire was pre-tested by three quality managers, which enabled the clarification of possible ambiguities, correction of errors and solution of formatting problems. This paper is part of a larger study that analyzes the current functioning of QM initiatives in Europe, but as the goal of this research was to study the Six Sigma initiative, we considered only responses from firms that had implemented this methodology. The larger global study had a target sample of 2500 organizations, from which 254 responses were obtained, representing a response rate of 10.16%. Of these, 17 responses were eliminated because they were incomplete or contained an error. Thus, the final sample was composed of 237 valid responses. Of these, only the respondents who indicated that they used the Six Sigma methodology to a reasonable degree (as discussed later) were used in this study. These numbered 58.

Of the total of 58 Six Sigma firms, 31.03% belong to the machinery and components sectors, 25.86% to different activities in the service sector, 20.68% to electricity and electronics, and the remaining 22.41% to miscellaneous sectors. As to the number of employees in each of the firms surveyed, 37.93% of the firms had from 51 to 250 employees, 36.20% from 251 to 1000, and 25.86% over 1000 workers. A breakdown of the countries of origin in the sample shows that most of the organizations analyzed are from Spain (55.17%). Italy also represents a significant part of the sample (18.96%). Finally, Austria and the United Kingdom represent 13.79% and 12.06%, respectively.

3.2. Construction of measurement scales

For teamwork, process management, absorptive capacity and organizational learning orientation scales, table I includes all sources used, items included and results obtained in the validation process. All the items in the scales were accompanied by a 7-point Likert-type scale (0=totally disagree; 7=totally agree).

Insert Table I about here

3.2.5. Implementation of quality management initiatives

Finally, to identify the implementation of the quality management initiatives, the questionnaire included a list of the different alternatives such as ISO Standards, the EFQM model, Six Sigma, the Deming model, quality control with a 7-point Likert, from 1 (minimal implementation) to 7 (maximum implementation). This allowed the firms to indicate the initiatives that they had underway and the degree of implementation associated with each of these.

3.3. Data analysis: Structural Equation Modelling (SEM) for Six Sigma firms

Firstly, we separated from the total research sample (237 responses) the organizations that indicated the implementation of the Six Sigma methodology (58 responses). Once the sample is distributed, we must determine through a SEM whether the greater degree of implementation of "teamwork" and "process management" in Six Sigma firms implies greater development of absorptive capacity, and how this affects organizational learning orientation. To perform this task, we used the programme "EQS Structural Equation Modelling Software". To ensure that there is no multicolinearity between the variables analysed we calculate the factors of inflation variance (FIV) and the condition index. The results obtained take values below the maximum recommended (Kleinbaum, 1988), eliminating the possibility of multicolinearity. Recommended values of fit indices (RMSEA, GFI, CFI, etc.) for satisfactory fit of a model to data are presented in Table II.

Insert Table II about here

Figure 1 depicts the SEM results of the relationships between teamwork and process management, absorptive capacity and learning orientation, in Six Sigma firms. Each path in the figure indicates the associated hypothesis as well as the estimated path coefficients and *t*-values (*t*-values for path coefficients greater than 1.65 are significant at $p<0.10$; *t*-values for path coefficients greater than 1.96 are significant at $p<0.05$; *t*-values for path coefficients greater than 2.58 are significant at $p<0.01$).

Insert Figure I about here

We can see that teamwork has a positive and significant effect ($p<0.01$) on absorptive capacity, leading us to accept Hypothesis 1. Hypothesis 2, which affirms that processes management in Six Sigma affects the organization's absorptive capacity positively and significantly, is also accepted. We can see how it has a positive and significant influence ($t=1.99$, $p<0.05$). Finally, Hypothesis 3, which establishes that absorptive capacity affects the organization's learning orientation, is also confirmed. The results of the model show a positive and significant influence ($t=1.43$, $p<0.01$).

4. Discussion of results

The main goal of this study is to observe whether the teamwork and process management proposed by the Six Sigma methodology influence positively the development of absorptive capacity in the organization. We analyse in greater empirical depth the possible reasons for Six Sigma initiative success. Further, this paper contributes to the emerging literature that analyses the effects of absorptive capacity on organizational learning orientation.

First, when we observe the effect of Six Sigma teamwork on absorptive capacity, we see that our results contribute to the literature supporting the positive relation between the mechanisms for integrating workers and absorptive capacity (Cohen and Levinthal, 1990; Jansen et al., 2005; Lane et al., 2006; Todorova and Durisin, 2007; Van den Bosch et al., 1999; Zahra and George, 2002). Until now, we have not had empirical evidence of this fact in organizations that implement the Six Sigma methodology. This result thus constitutes an important research contribution. As mentioned above, one of the most important characteristics of Six Sigma is teamwork. It is a methodology that grounds much of its functioning in teamwork (Breyfogle, 2003; Pande et al., 2002). The work teams are cross-functional, interdepartmental teams with coordination mechanisms that facilitate the exchange of knowledge between units. These teams are constructed in an open and supportive climate (Dahlgaard and Dahlgaard-Park, 2006; Lloréns et al., 2006), which facilitates creativity and communication between workers. Tu et al. (2006) have indicated that organizational climate, and in this case an open and supportive climate, has positive repercussions for absorptive capacity. This study continues the line of research begun by Park et al. (2009), who confirmed that Six Sigma teams permit the creation and capturing of information, the storing and sharing of information, and the use of information in the DMAIC cycle. Our study allows us to affirm that Six Sigma teams enable the development of their absorptive capacity, contributing to learning, as we will see later. Our study also contributes to Jansen et al. (2005) work, although it does not manage to determine whether this positive effect is due to the lateral communication mechanisms that influence the first two phases (acquisition and assimilation), or whether the effect is due to the combination of knowledge that affects the last two phases (transformation and exploitation). Future lines of study can achieve the depth achieved in the study by Jansen et al. (2005).

Secondly, Lloréns et al. (2006) have established theoretically that Six Sigma teamwork differs from teamwork included in other quality initiatives, mainly due to the creation of specialized positions to run its projects rather than overloading the firm's managers. Further, the Black Belts and Green Belts are responsible for leading teams and improvement projects (Gitlow, 2005; Pande et al., 2002). To do this, they foster the participation of the workers, formalize the work that they perform and encourage the workers to work as a team. People in these positions direct learning efforts (Choo et al., 2007; Wiklund and Wiklund, 2002), becoming a resource available to help in the development of absorptive capacity (Choo et al., 2007). Further, according to Lenox and King (2004, p.331), "managers can develop absorptive capacity by directly providing information to agents in the organization". This work of information provision can be performed by the positions created in Six Sigma work teams, primarily by the "Champions" and the "Master Black Belts", the positions of greatest responsibility, constituting a very important contribution to the development of absorptive capacity.

Third, once the positive effect of Six Sigma on shared vision have been confirmed (Gutierrez et al., 2009), our study shows how two of the elements that contribute most to developing a shared vision, teamwork and process management, also contribute to absorptive capacity. As to teamwork, one of the concepts on which we have grounded the reasoning of this paper is the orientation of Six Sigma to specific and challenging goals (Linderman et al., 2003; 2006). The specific goals established by Six Sigma are shared by its members, creating a common future image, the shared vision (Pearce and Ensley, 2004). Further, the highly challenging goals that Six Sigma establishes (Pande et al., 2002, Linderman et al., 2003; 2006) develop more cohesive groups with better communication and cooperation. As a result, shared vision stimulates trust among employees (Abrams et al., 2003; Kolzow, 1999), also present in Six Sigma (Choo et al., 2007), which has positive repercussions for absorptive capacity, as it facilitates the relation between the sending and the receiving units (Lane et al., 2001). Further, as we have shown, the specific goals focus attention on potentially useful knowledge (Huber, 1991; Nonaka, 1994), which in Six Sigma enables the workers to dedicate their absorption efforts to the goals indicated. On the other hand, for process management, the common use of all of the tools included in Six Sigma contributes to facilitating communication between workers, developing a shared language, eliminating possible conflicts and misunderstandings, and increasing the cohesion of groups. This affects shared vision (Gutierrez et al., 2009) and absorptive capacity, as it permits the development of what Gupta and Govindarajan (2000) call "homophily". Six Sigma is a methodology whose shared language, tools, etc., enhance similarity between work units, e.g. between groups of workers who manage processes, and thus greatly facilitate knowledge absorption. Lane and Lubatkin (1998) and Lane et al. (2001) introduced the concept of relative absorptive capacity. This concept indicates that the ability of one firm to learn from another is determined by the relative characteristics of each firm. Thus, absorptive capacity will be greater when culture is shared (norms, values, etc.) or when the firms have similar operating priorities (similar business, etc.). If we translate this concept to an internal perspective, as Tu et al. (2006) do with the definition of absorptive capacity, Six Sigma typically brings about a cultural change in the organization. Lee et al. (2009) identify this change as the most important aspect of the methodology. Thus, the right cultural change, with a clear communication plan and channels that motivate the employees to overcome resistance to change (Antony and Bañuelas, 2001) will produce work units that share all of the characteristics indicated by Lane and Lubatkin (1998) and Lane et al. (2001), developing the presence of relative absorptive capacity.

Fourthly, although process management in Six Sigma methodology, may not contribute any new content (Gijo et al., 2005) it does differentiate this initiative from others by granting quality management greater structure and formality (Breyfogle, 2003; Pande et al., 2002). The greater formality and structuring of the statistical techniques used offer another possible explanation for the success of Six Sigma. The great importance attributed to statistical process control in Six Sigma makes it the strongest technique for quality improvement from the statistical perspective (Lloréns et al., 2006). This differentiates it from other initiatives that are weaker from the perspective of, for example, the ISO standards. This formality and structuring of Six Sigma process management points toward the line of study developed by Choo et al. (2007). Our study enriches this research line, since the authors, with Zu et al. (2008), argue that these are the reasons that Six Sigma facilitates knowledge acquisition. Our study has shown empirically the positive effect on an intermediate variable, absorptive capacity.

This study thus adds to the small number of empirical studies that observe the positive effects of Six Sigma on organizations (Antony et al., 2005; 2007; Lee et al., 2006; Gutiérrez et al., 2009). Our results allow us to explain Six Sigma's success from a perspective of teamwork and process management used. We do not see the direct relation of the Six Sigma practices to variables of performance such as improvement in competitiveness (Lee et al., 2006), profitability or market share (Antony et al., 2005; 2007). However, the results show a positive effect on an intermediate variable, *absorptive capacity*, which, as we will discuss next, affects another variable fundamental to obtaining competitive advantage, organizational learning. This study thus provides a possible reason for Six Sigma's positive results, one that follows the lines of Choo et al. (2004; 2007), who observe that formality and structuring in Six Sigma firm affect knowledge creation positively. We must not forget, however, that part of the literature supports a relationship in the opposite direction, where knowledge management constitutes an aid to quality management (Darroch and McNaughton 2003; 2005; Darroch et al., 2003; Gowen et al., 2008; Yeung et al., 2007).

Finally, the results show a positive and significant effect of absorptive capacity on organizational learning orientation. Because this relationship is already justified in the literature (Cohen and Levinthal, 1990; Lane et al., 2001; 2006; Lyles et al., 1996; Tu et al., 2006), the contribution of our study lies in observing this relationship in the context of the Six Sigma initiative, thus establishing a connection of practices like teamwork and process management to organizational learning by means of absorptive capacity, an issue absent in the research literature and whose exploration has been requested by previous studies (Choo et al., 2007; Gowen et al., 2008; Wiklund and Wiklund, 2002). However, we wish to make two important comments that may orient future lines of research. First, the relationship between learning and absorptive capacity can have a circular structure. Thus, "increased learning in a particular area enhances the organization's knowledge base in that area, which further increases absorptive capacity and, thus, facilitates more learning in that domain" (Autio et al., 2000; Barkema and Vermeulen, 1998; Lane et al., 2006). Second, taking into account the studies by Lichtenthaler (2009) and Lane et al. (2006) and the distinction between exploratory and exploitative learning, and between potential and realized absorptive capacity, one could develop in greater depth the study of which phases of knowledge absorption are affected by Six Sigma practices, since each of these phases is necessary but not sufficient for completing the absorption process successfully.

5. Summary and conclusions

This study contributes to developing empirical knowledge of the benefits of the implementation of quality management initiatives in the firm. Specifically, it examines the effects of implementing the Six Sigma quality management initiative to provide a possible explanation of the initiative's good results. Teamwork and process management in Six Sigma differentiate it from the rest of the initiatives and lead to the development of a greater absorptive capacity. Both constructors have been shown to have positive and significant effect on absorptive capacity. Further, the results obtained show empirical support for the positive effect of absorptive capacity on organizational learning orientation within the framework of the Six Sigma methodology.

This study enables us to draw some practical implications for managers. Currently, the market offers a wide variety of initiatives for managing quality (ISO standards, Malcolm Baldridge, EFQM model, Six Sigma, Lean Manufacturing, etc). The results obtained permit us to provide a more detailed description of one of these initiatives, observing two practices that can help to differentiate it (teamwork and process management) and which have positive effects for the organization. This knowledge can be very useful for managers who find themselves faced with the decision of choosing between various options for managing quality, especially those whose organizations operate in environments where absorptive capacity and learning organizations are very important. The findings of this study offer a justification of Six Sigma implementation in firms. Further, the results drive the development of absorptive capacity within organizations, due to their positive relation, in this case, to orientation to learning. Besides, we must remark that the role of management is crucial in this development.

Some of the main lines for future research have been mentioned in the previous section. These include studying in greater depth the effects of Six Sigma practices on the different phases of knowledge absorption (potential and realized absorptive capacity). It could also be valuable to examine the Six Sigma methodology from a perspective of cultural change in the organization, considering how cultural change can affect relative absorptive capacity. In any case, the literature on the methodology and its effects on performance, is still scarce, such that all of the knowledge obtained on the functioning and results will be very helpful. Thus, other structural aspects of this methodology, such as supplier management (Bañuelas et al., 2003; Breyfogle, 2003) and design of products, processes and services (DFSS[†]) (Breyfogle, 2003; Pande et al., 2002), could also serve as an orientation for continuing in-depth analysis of the real reasons for the success of Six Sigma.

Finally, among the limitations of our study, we must include the fact that Six Sigma implementation is examined using a single item testing its development degree, instead of a compound construct. The sample of Six Sigma firms is not distributed uniformly between the observed countries. Together with the cross-sectional character of the research, this factor somewhat limits generalization from our results. Further, longitudinal research that analyses a greater number of cases and that observes effects on real results of organizations could enrich the literature on the Six Sigma quality management initiative and the success it brings.

References

Abrams, L.C., Cross, R.C., Lesser, E. and Levin, D.Z., 2003. Nurturing interpersonal trust in knowledge-sharing networks, *Academy of Management Executive*, 17 (4), 64-79.

Actualidad Económica, 2004. *Cuáles son, cuánto venden y quién manda en las 5.000 mayores empresas*, Octubre 2004, No 2419.

Anderson, J.C., Rungtusanatham, M., Schroeder, R.G. and Devaraj, S., 1995. A Path Analytic Model of a Theory of Quality Management Underlying the Deming Management Method: Preliminary Empirical Findings. *Decision Sciences,* 26 (5), 637-658.

Antony, F., Kumar, M. and Choo, B., 2007. Six sigma in service organisations: Benefits, challenges and difficulties, common myths, empirical observations and success factors. *International Journal of Quality & Reliability Management*, 24 (3), 294-311.

Antony, F., Kumar, M. and Madu, C., 2005. Six sigma in small- and medium-sized UK manufacturing enterprises: Some empirical observations. *International Journal of Quality & Reliability Management*, 22 (8), 860-874.

Antony, J. and Bañuelas, R., 2001. Six Sigma: A business strategy for manufacturing organizations. *Manufacturing Engineering*, 80 (3), 119-121.

Autio, E., Sapienza, H.J. and Almeida, J.G., 2000. Effects of age at entry, knowledge intensity, and imitability on international growth. *Academy of Management Journal*, 43 (5), 909-924.

Bañuelas, R. and Antony, F., 2003. Going from six sigma to design for six sigma: an exploratory study using analytic hierarchy process. *The TQM Magazine*, 15 (5), 334-344.

Barkema, H.G. and Vermeulen, F., 1998. International expansion through start-up or acquisition: A learning perspective. *Academy of Management Journal,* 41 (1), 7-26.

Breyfogle, F.W., 2003. *Implementing Six Sigma: Smarter Solutions Using Statistical Methods*, New Jersey: Ed. Wiley.

Byrne, B.M., 1998. *Structural Equation Modelling with Lisrel, Prelis and Simplis: Basic concepts, Application, and Programming*. Lawrence Erlbaum, Mahwah, NJ.

[†] DFSS="Design for Six Sigma".

Calantone, R.J., Cavusgil, S.T. and Yushan, Z., 2002. Learning orientation, firm innovation capability and firm performance. *Industrial Marketing Management* 31 (6), 515-524.
Cheng, J., 2009. Six Sigma and TQM in Taiwan: An empirical study of discriminate analysis. *Total Quality Management & Business Excellence,* 20 (3), 311-326.
Chiles, T.H. and Choi, T.Y., 2000. Theorizing TQM: An Austrian and Evolutionary Economics Interpretation. *Journal of Management Studies,* 37 (2), 185-212.
Choo, A.S., Linderman, K., and Schroeder, R.G., 2004. Social and methods effects on learning behaviours and knowledge creation in Six Sigma projects. In: *Proceedings of 2004 Annual Meeting of the Academy of Management*, New Orleans, LA.
Choo, A.S., Linderman, K.W. and Schroeder, R.G., 2007. Method and context perspectives on learning and knowledge creation in quality management. *Journal of Operations Management*, 25, 918-931.
Cohen, W. and Levinthal, D., 1990. Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly,* 35 (1), 128-152.
Cole, R.E., Bacdayan, P. and White, B.J., 1993. Quality, Participation and Competitiveness. *California of Management Review*, 35 (3), 68-81.
Cooper, N., 2003. Do Teams and Six Sigma go together?. *Quality Progress*, 36 (6), 25-29.
Daft, R.L. and Lengel, R.H., 1998. Organizational information requirements, media richness and structural design. *Management Science*, 32 (5), 554-572.
Dahlgaard, J.J. and Dahlgaard-Park, S.M., 2006. Lean production, six sigma quality, TQM and company culture. *The TQM Magazine*, 18 (3), 263-281.
Darroch, J., 2005. Knowledge management, innovation and firm performance. *Journal of Knowledge Management*, 9 (3), 101-115.
Darroch, J. and McNaughton, R., 2003. Beyond market orientation: knowledge management and the innovativeness of New Zealand firms. *European Journal of Marketing*, 37 (3/4), 572-593.
De Mast, J., 2006. Six Sigma and competitive advantage. *Total Quality Management & Business Excellence*, 17 (4), 455-464.
Flynn, B.B., Sakakibara, S. and Schroeder, R.G., 1995. Relationship between JIT and Total Quality Management: practices and performance. *Academy of Management Journal*, 8 (5), 1325-1360.
Fosfuri, A. and Tribó, J.A., 2008. Exploring the antecedents of potential absorptive capacity and its impact on innovation performance. *Omega*, 36 (2), 173-187.
Gijo, E.V. and Rao, T.S., 2005. Six Sigma implementation – Hurdles and more hurdles. *Total Quality Management & Business Excellence*, 16 (6), 721-725.
Gitlow, H., 2005. *Six Sigma for green belts and champions: foundations, DMAIC, tools, cases, and certification*. US Prentice Hall Ed.2005.
Goh, T.N., Low, P.C., Tsui, K.L. and Xie, M., 2003. Impact of Six Sigma implementation on stock price performance. *Total Quality Management & Business Excellence*, 14 (7), 753-763.
Gowen, C.R., Stock, G.N. and Mcfadden, K.L., 2008. Simultaneous implementation of Six Sigma and knowledge management in hospitals. *International Journal of Production Research*, 46 (23), 6781- 6795.
Green, F., 2006. Six Sigma and the revival of TQM. *Total Quality Management & Business Excellence,* 17 (10), 1281-1286.
Gupta, A. and Govindarajan, V., 2000. Knowledge flows within multinational corporations. *Strategic Management Journal,* 21 (4), 473-496.

Gutierrez-Gutierrez, L., Lloréns-Montes, F.J. and Bustinza, O., 2009. Six Sigma: From a goal-theoretical perspective to shared-vision development. *International Journal of Operations and Production Management*, 29 (2), 151-169.
Hair, J.F., Anderson, R.E., Tatham, R.L. and Black, W.C., 2004. *Análisis multivariante*. 5th Ed. Madrid: Prentice Hall.
Hann, G.J., Hill, W.L., Hoerl, R.W. and Zinkgraf, S.A., 1999. The impact of Six Sigma improvement-a glimpse in the future of statistics. *The American Statistician*, 53 (3), 208-215.
Harry, M.J., 2000. *Six Sigma*, New York: Currency.
Howell, R., 1987. Covariance Structure modeling on the personal computer. *Journal of Marketing Research*, 24 (4), 456-459.
Huber, G.P., 1991. Organizational learning: the contributing processes and the literature. *Organization Science*, 2 (1), 88-115.
Huber, G.P., 1996. Organizational learning: a guide for executives in technology-critical organizations. *International Journal of Technology Management*, 11 (7), 821-832.
Hult, G.T.M. and Ferrell, O.C., 1997. A global learning organization structure and market information processing. *Journal of Business Research*, 40 (2), 155–166.
Jansen, J., Van Den Bosch, F. and Volberda, H., 2005. Managing potential and realized absorptive capacity: how do organizational antecedents matter? *Academy of Management Journal*, 48 (6), 999-1015.
Kanji, G.K., 2008. Reality check of Six Sigma for Business Excellence. *Total Quality Management & Business Excellence*, 19 (6), 575-582.
Kaushik, P. and Khanduja, D., 2009. Application of Six Sigma DMAIC methodology in thermal power plants: A case study. *Total Quality Management & Business Excellence*, 20 (2), 197-207.
Kim, L., 1998. Crisis construction and organizational learning: Capability building in catching-up at Hyundai Motor. *Organization Science*, 9 (4), 506–521.
Kleinbaum, D.G., Kupper, L.L., and Muller, K.E., 1988. Applied regression analysis and other multivariate analysis methods.Boston, MA: PWS - Kent Publishing Company.
Kolzow, D., 1999. A Perspective on Strategic Planning: What's your vision? *Economic Development Review*, 16 (2), 5-10.
Lane, P.J. and Lubatkin, M., 1998. Relative absorptive capacity and interorganizational learning". *Strategic Management Journal*, 19 (5),461-477.
Lane, P.J., Koka, B. and Pathak, S., 2006. The reification of absorptive capacity: a critical review and rejuvenation of the construct. *Academy of Management Review*, 31 (4), 833-863.
Lane, P.J., Salk, J. and Lyles, M., 2001. Absorptive Capacity, Learning, and Performance in International Joint Ventures. *Strategic Management Journal*, 22 (12), 1139-1161.
Lapré, M.A., Mukherjee, A.S. and Van Wassenhove, L.N., 2000. Behind the learning curve: linking learning activities to waste reduction. *Management Science*, 46 (5), 597-611.
Lee, K. and Choi, B., 2006. Six sigma management activities and their influence on corporate competitiveness. *Total Quality Management & Business Excellence*, 17 (7), 893-911.
Lee, K., Wei, C. and Lee, H., 2009. Reducing exposed copper on annular rings in a PCB factory through implementation of a Six Sigma project. *Total Quality Management & Business Excellence*, 20 (8), 863 – 876.
Lenox, M. and King, A., 2004. Prospects for developing absorptive capacity through internal information provision. *Strategic Management Journal*, 25 (4), 331-345.

Liao, J., Welsch, H. and Stoica, M., 2003. Organizational Absorptive Capacity and Responsiveness: An Empirical Investigation of growth oriented SMEs. *Entrepreneurship Theory and Practice*, 28 (1), 63-85.
Lichtenthaler, U., 2009. Absorptive capacity, environmental turbulence, and the complementarity of organizational learning processes. *Academy of Management Journal*, 52 (4), 822-846.
Linderman, K. and Schroeder, R.G., Choo, A.S., 2006. Six Sigma: the role of goal in improvement teams. *Journal of Operations Management*, 24 (6), 779-790.
Linderman, K., Schroeder, R.G., Zaheer, S. and Choo, A.S., 2003. Six Sigma: a goal-theoretic perspective. *Journal of Operations Management*, 21 (2), 193-203.
Lloréns, F.J. and Molina, L.M., 2006. Six Sigma and management theory: processes, content and competitiveness. *Total Quality Management & Business Excellence*, 17 (4), 485-506.
Locke, E.A. and Latham, G.P., 1990. *A theory of goal setting and task performance*. Prentice Hall, Englewood Cliffs, NJ.
Lowenthal, J.N., 2002. *Guía para la aplicación de un proyecto Seis Sigma*. Madrid: Ed. FC Editorial.
Lucas, M.L., 2002. The essential Six Sigma: how successful six sigma implementation can improve the bottom line. *Quality Progress*, 35 (1), 2-32.
Lucier, G.T. and Seshadri, S., 2001. GE takes Six Sigma beyond the bottom line. *Strategic Finance*, 82 (11), 40-46.
Lyles, M.A. and Salk, J.E., 1996. Knowledge acquisition from foreign parents in international joint ventures: An empirical examination in the Hungarian context. *Journal of International Business Studies*, 27 (5), 877-904.
Malhotra, A., Gosain, S. and El Sawy, O., 2005. Absorptive capacity configurations in supply chains: gearing for partner- enabled market knowledge creation. *MIS Quarterly*, 29 (1), 145-188.
Mason, B. and Antony, J., 2001. Statistical process control: an essential ingredient for improving service and manufacturing quality. *Measuring Business Excellence*, 5 (4), 47-52.
Nonaka, I., 1994. A dynamic theory of organizational knowledge creation. *Organization Science*, 5 (1), 14-37.
Oakland, J.S., 1989. *Total Quality Management: The Route for Improving Performance*. Oxford: Butterworth-Heinemann.
Pande, P.S., Neuman, R.P. and Cavanagh, R.R., 2002. *Las claves de Seis Sigma: La implantación con éxito de una cultura que revoluciona el mundo empresarial*. Madrid: Ed. McGraw Hill.
Park, S.H., Ntuen, C.A. and Park, E.H., 2009. A new paradigm of Six Sigma: Knowledge-based Digital Six Sigma. *Total Quality Management & Business Excellence*, 20 (9), 945-952.
Pearce, C.L. and Ensley, M.D., 2004. A reciprocal and longitudinal investigation of the innovation process: the central role of shared vision in product and process innovation teams (PPITs). *Journal of Organizational Behaviour*, 25 (2), 259-278.
Ravichandran, J., 2006. Six-Sigma Milestone: An Overall Sigma Level of an Organization. *Total Quality Management & Business Excellence*, 17 (8), 973-980.
Rindova, V.P. and Fombrun, C.J., 1999. Constructing competitive advantage: the role of firm-constituent interactions. *Strategic Management Journal*, 20 (8), 691-710.
Rogers, E. M., 1995. *Diffusion of Innovations*. Free Press, New York

Rungtusanatham, M., Anderson, J.C. and Dooley, K.L., 1997. Conceptualizing Organizational Implementation and Practice of Statistical Process Control. *Journal of Quality Management*, 2 (1), 113-137.
Saraph, J.V., Benson, P.G. and Schroeder, R.G., 1989. An Instrument for Measuring the Critical Factors of Quality Management. *Decision Sciences*, 20 (4), 810-830.
Schilling, M.A., 2002. Technology success and failure in winner-take-all markets: the impact of learning orientation, timing, and network externalities. *Academy of Management Journal*, 45 (2), 387-398.
Schroeder, R.G., Linderman, K., Liedtke, C. and Choo, A.S., 2008. Six Sigma: Definition and underlying theory. *Journal of Operations Management*, 26 (4), 536-554.
Senge, P., 1999. It's the learning: the real lesson of the quality movement. *Journal for Quality and Participation*, 22 (6), 34-40.
Shamji, N., 2005. Six Sigma Basics. *Total Quality Management*, 16 (5), 567-574.
Silos, I.M., 1999. Employee involvement-a component of Total Quality Management. *Production and Inventory Management Journal*, 40 (1), 56-65.
Sinha, K.K. and Van de Ven, A.H., 2005. Designing work within and between organizations. *Organization Science*, 16 (4), 389-408.
Sinkula, J.M., Baker, W.E. and Noordewier, T.A., 1997. Framework for market-based organizational learning: linking values, knowledge, and behaviour. *Journal of Academic Marketing Science*, 25 (4), 305–318.
Sousa, R. and Voss, C.A., 2002. Quality management re-visited: A reflective review and agenda for future research. *Journal of Operations Management*, 20 (1), 91-109.
Szulanski, G., 1996. Exploring internal stickiness: Impediments to the transfer of best practice within the firm. *Strategic Management Journal*, 17 Winter Special Issue, 27-43.
Thawani, S., 2004. Six Sigma-strategy for organizational excellence. *Total Quality Management*, 15 (5/6), 655-664.
Tien Shang, L. and Hsin Ju, T., 2005. The effects of business operation mode on market orientation, learning orientation and innovativeness. *Industrial Management & Data Systems*, 105 (3), 325-348.
Todorova, G. and Durisin, B., 2007. Absorptive capacity: valuing a reconceptualization. *Academy of Management Review*, 32 (3), 774-786.
Tsai, W., 2001. Knowledge transfers in Intra-Organizational Networks. *Academy of Management Journal*, 44 (5), 996-1004.
Tu, Q., Vonderembse, M.A., Ragu-Nathan, T.S. and Sharkey, T.W., 2006. Absorptive capacity: Enhancing the assimilation of time-based manufacturing practices. *Journal of Operations Management*, 24, 692-710.
Tubbs, M.E., 1986. Goal setting: a meta-analytic examination of the empirical evidence. *Journal of Applied Psychology*, 71, 474–483.
Van Den Bosch, F., Volberda, H. and De Boer, M., 1999. Coevolution of firm absorptive capacity and knowledge environment: organizational forms and combinative capabilities. *Organization Science*, 10 (5), 551-568.
Van Iwaarden, I., Van Der Wiele, T., Dale, B., Williams, R. and Bertsch B., 2008. The Six Sigma improvement approach:a transnational comparison. *International Journal of Production Research*, 46 (23), 6739-6758.
Wiklund, H. and Wiklund, P.S., 2002. Widening the Six Sigma concept: an approach to improve organizational learning. *Total Quality Management*, 13 (2), 233-239.
Yeung, A.C.L., Lai, K.H. and Yee, R.W.Y., 2007. Organizational learning, innovativeness, and organizational performance: a qualitative investigation. *International Journal of Production Research*, 45 (11), 2459-2477.

Zahra, S. and George, G., 2002. Absorptive Capacity: A review, reconceptualization, and extension. *Academy of Management Review*, 22 (2), 185-203.
Zahra, S., Ireland, R.D. and Hutt. M.A., 2000. International expansion by new venture firms: international diversity, mode of market entry, technological learning, and performance. *Academy of Management Journal*, 43 (5), 925-950.
Zu, X., Fredendall, L.D. and Douglas, T.J., 2008. The evolving theory of quality management: The role of Six Sigma. *Journal of Operations Management*, 26 (5), 630-650.

Table I Scales. Sources, Means, Standard Deviation and validation

Construct	Source	Mean	S.D.	Standardized factor loadings (>0.4[a])	t-value (t>1.96, p<0.05 [a])	Cronbach's Alpha
Teamwork	Flynn et al. (1995)					0.845
1. Our plant is organized into permanent production teams (Item deleted after internal consistency analysis).		5.5000	1.53611	Item eliminated	-	
2. Our plant forms teams to solve problems.		5.3793	1.56528	Item eliminated	-	
3. In the past three years, many problems have been solved through small group sessions.		5.4483	1.25897	0.54	4.009	
4. Supervisors encourage the persons who work for them to exchange opinions and ideas.		5.3793	1.24008	0.81	7.034	
5. Supervisors encourage the people who work for them to work as a team.		5.3793	1.22586	0.90	7.414	
6. Supervisors frequently hold groups meetings where the people who work for them can really discuss things together.		5.0517	1.56073	0.83	8.768	
Process Management	Anderson et al. (1995)					0.806
1. Charts showing defect rates are posted on the shop floor.		4.5517	2.20185	Item eliminated	-	
2. Charts plotting frequently of machine breakdowns are posted on the shop floor (Item deleted after validity analysis).		3.6724	2.30475	Item eliminated	-	
3. We have standardized process instructions which are given to personnel.		5.8621	1.31720	0.53	3.877	
4. A large percent of the equipment or process on the shop floor are currently under statistical quality control.		4.6897	1.90297	0.86	6.761	
5. We make extensive use of statistical techniques to reduce variance in processes.		4.5172	1.89405	0.92	6.149	
Absorptive capacity	Szulanski (1996)					0.863
ıe new knowledge acquired is in agreement with :ing knowledge in the organisation (Item deleted after uniduunidimensionalty analysis).		5.6207	1.04003	Item eliminated	-	
2. Organization has a clear division of roles and responsibilities to exploit new knowledge.		5.5172	1.11200	0.62	4.793	
3. Organization has the necessary skills to use new knowledge obtained.		5.5690	.99317	0.89	8.634	
4. Organization has the technical competence to absorb new knowledge.		5.7241	1.12067	0.85	8.473	
5. Organization has the managerial competence to absorb new knowledge.		5.4483	1.23078	0.79	7.032	
6. It is well known who can best exploit new information and new knowledge.		5.4828	.97767	Item eliminated	-	
Organizational learning orientation	Sinkula et al. (1997) and Hult et al. (1997)					0.924
1. Our organization is a learning organization		5.7586	1.41806	0.80	7.064	
2. The sense around here is that employee learning is an investment, not an expense		5.7069	1.38929	0.89	7.103	
3. Once we quit learning we endanger our future		6.0690	1.46134	0.95	8.165	
4. The basic values of this organization include learning as a key to improvement		5.8448	1.38667	0.96	8.363	
5. Our ability to learn is the key to improvement		5.8621	1.35657	0.93	8.0532	

[a]Hulland (1999).

Table II. Goodness of fit statistics of the structural model

Goodness of Fit Statistics	Structural Model	Recommended values for satisfactory fit of a model to data
χ^2 (sig.)	337.48	
Freedom negrees	120	
χ^2 / df	2.812	<3.0[a]
Root Mean Square Error of Approximation (RMSEA)	0.078	<0.08 [b]
Goodness of Fit Index (GFI)	0.92	>0.5[b]
Akaike's Information Criterion (CAIC)	399.25	< Saturated model and independence model [a]
CAIC for saturated model	688.22	
CAIC for independence model	1441.17	
Parsimony Goodness of Fit Index (PGFI)	0.71	>0.5[b]
Parsimony Normed Fit Index (PNFI)	0.75	>0.5[b]
Comparative Fit Index (CFI)	0.91	>0.5[b]

[a]Hair et al. (2004) y Byrne (1998).

[b]Byrne (1998).

Figure 1.Structural modelling of the relationship between Teamwork and Process Management in Six Sigma firms, absorptive capacity and learning orientation