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The knowledge transfer process in Six Sigma subsidiary firms

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Abstract

Although the operative benefits of Six Sigma methodology in the business world are well accepted, the long-term benefits of the initiative are currently under discussion. This paper aims to analyze how Six Sigma methodology is related to the knowledge transfer process, a source of competitive advantage. For this purpose, we observe how team management in Six Sigma firms differs statistically from team management proposed by other quality management initiatives, and how Six Sigma team management is related to the knowledge integration and knowledge transfer processes. An ANOVA analysis and Partial Least Squares (PLS) approach were used to analyze data from 53 European Six Sigma firms, confirming the hypotheses developed. The results confirm that Six Sigma methodology offers new possibilities to companies and that implementation of Six Sigma has a positive effect on variables that influence long-term organizational performance, such as knowledge management. Relevant academic contributions and implications for practitioners are included.

Keywords

Six Sigma; continuous improvement; total quality management; knowledge management; competitive advantage

1. Introduction

It is a generally accepted premise in quality management research that organizational success derives from Six Sigma implementation. Studies analyzing the relationship between Six Sigma implementation and performance are increasingly common (e.g., Braunscheidel, Hamister, Suresh and Star, 2011; Choi, Kim, Leem, Lee and Hong, 2012; Shafer and Moeller, 2012; Swink and Jacobs, 2012). Despite the positive relationship often found in research (e.g., Braunscheidel et al., 2011; Choi et al., 2012; Shafer and Moeller, 2012; Swink and Jacobs, 2012), a significant controversy about the real benefits

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of Six Sigma implementation remains unresolved (Braunscheidel et al., 2011; Mellat, 2011; Nair, Malhotra and Ahire, 2011).

Recent research has focused on long-term strategic variables and on the possibility of obtaining a competitive advantage from Six Sigma implementation (DeMast, 2006; Gowen and Tallon, 2005; Swink and Jacobs, 2012). Using the dynamic capabilities perspective, Swink and Jacobs (2012) affirm that learning and adaptation resulting from Six Sigma can lead to competitive advantage. These results prompted a call for research on other related theories (Gamal, 2010; Linderman, Schroeder, Zaheer and Choo, 2003), especially knowledge management variables (Anand, Ward and Tatikonda, 2010; Choo, Linderman and Schroeder, 2007; Linderman et al., 2003; Schroeder, Linderman, Liedtke and Choo, 2008), that may lead to sustainable competitive advantage (DeMast, 2006; Llorens and Molina, 2006).

Current research efforts are thus devoted to analyzing the relationship between Six Sigma and knowledge management. Results show positive relationships between Six Sigma and variables such as organizational learning (e.g., Choo et al., 2007; Llorens and Molina, 2006; Malik and Blumenfeld, 2012; Wiklund and Wiklund, 2002), knowledge creation (e.g., Anand et al., 2010; Choo et al., 2007), absorptive capacity (e.g., Gutierrez Bustinza and Barrales-Molina, 2012; McAdam and Hazlett, 2010), and shared vision (Gutierrez, Llorens-Montes and Bustinza, 2009; Malik and Blumenfeld, 2012). The variable knowledge transfer has received no attention in the Six Sigma literature but is a promising focus for research due to the important benefits associated with this process.

There is general agreement that knowledge transfer plays a fundamental role in successful organizations today (Scott and Fields, 2010). The literature shows how knowledge transfer impacts organizational performance positively (Argote and Ingram, 2000; Paulus and Yang, 2000). Some studies have even suggested that knowledge transfer is a basis for obtaining competitive advantage (Babcock, 2004; Cabrera and Cabrera, 2002; Szulanski, 1996). Academic research has also taken note of knowledge transfer, and the number of related publications is growing constantly (Kumar and Ganesh, 2009).

The main purpose of this paper is to study the relationship between Six Sigma implementation and knowledge transfer processes. To achieve this goal, we test a set of hypotheses in a survey of European firms, using ANOVA and partial least squares analyses. The theoretical model attempts to explain how Six Sigma variables such as team management influence knowledge integration and knowledge transfers.

This paper contributes to the academic literature in several ways. Firstly, our research explores the behavior of a new knowledge-related variable in the Six Sigma context, in response to calls in the recent literature. Secondly, it contributes to the line of research on Six Sigma implementation and strategic variables that could explain how competitive advantage is obtained. The relationships observed give the paper an added value, as these relationships have not been tested in previous research. Finally, the paper provides solid empirical evidence of Six Sigma successful implementation. The study also benefits practitioners in establishing positive implications derived from Six Sigma. The variables observed, such as team management, also offer practical guidance for managers who seek to obtain successful Six Sigma implementation. All of these implications motivate Six Sigma adoption.

The paper is structured as follows. Following this introduction, the second section presents a theoretical review of Six Sigma and knowledge transfer, including formulation

of the hypotheses. The third section explains the methodology used to develop the empirical analysis. Section four presents the results obtained. The fifth section discusses the results obtained. Finally, the sixth section develops the main conclusions of this paper, its limitations, and lines for further research.

2. Theoretical development

2.1.Six Sigma teamwork 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). Despite the interest evident in the literature, Six Sigma's continuous improvement initiative has been criticized because its approach does not add new tools and contributions to the field of quality management (QM) (Gijo and Rao, 2005; Schroeder et al., 2008; Zu, Fredendall and Douglas, 2008). In response to this criticism, Zu et al. (2008) and Schroeder et al. (2008) attempt to identify what is new in Six Sigma, questioning specifically whether "the philosophy and tools/techniques of Six Sigma are strikingly similar to prior quality management approaches" (Schroeder et al., 2008, p.537). These studies identify specific features based on which the authors affirm important advances in Six Sigma methodology that differentiate it from Total Quality Management (TQM) (Brun, 2011; Kwak and Anbari, 2006; Schroeder et al., 2008; Zu et al., 2008).

One of the distinctive aspects of the Six Sigma methodology is the role that team management plays in the initiative. Six Sigma methodology pursues continuous improvement, using teams to carry out improvement projects. These teams constitute the basic unit for organizational improvement in Six Sigma initiatives (Gutierrez et al., 2012; Pande, Neuman and Cavanagh, 2000; Shamji, 2005). Managers' role employed in Six Sigma improvement teams is different from those in other QM initiatives. They are specialists assigned to specific leadership roles and responsibilities in improvement teams, they have received a high level of training, and they dedicate themselves to these tasks full-time so that they are not overworked (Brun, 2011; Schroeder et al., 2008; Zu et al., 2008). Gowen and Tallon (2005) identify practices associated with team management, so-called "Black Belt practices", as practices more closely related to competitive advantage dimensions–added value, rareness, high imitation cost, and non-substitutability. We can thus affirm that team management practice constitutes a specific feature of Six Sigma methodology that could lead the organization to higher performance levels. Consequently, we establish the first hypothesis:

H1: Team management practice in Six Sigma firms is statistically different from team management practice in firms with other QM initiatives.

2.2.Six Sigma and knowledge management

As affirmed above, the literature calls for a line of research to analyze the relationship between Six Sigma and the field of knowledge management (Anand et al., 2010; Choo et al., 2007; Linderman et al., 2003; Schroeder et al. 2008). This call has inspired some empirical studies on the topic. Choo et al. (2007) observes Fortune 500 manufacturing firms and concludes that there are positive relationships between Six Sigma's psychological safety and learning behaviors, and between Six Sigma's structured method

and knowledge creation. Anand et al. (2010) observe that Six Sigma projects facilitate knowledge creation and consequently the success of these projects. Analyzing four Indian firms, Malik and Blumenfeld (2012) find that Six Sigma practices—commitment to quality and information sharing, continuous improvement, and teamwork—are positively related to organizational learning capability. Finally, Gutierrez et al. (2012) observe 58 European Six Sigma manufacturing and service firms and determine both that teamwork and process management in these firms are positively related to absorptive capacity and that absorptive capacity is positively related to learning orientation. We can thus affirm that there is general agreement about the positive relationship between Six Sigma implementation and knowledge-related variables. No study has focused, however, on analyzing the variable knowledge transfer.

To explain the knowledge transfer process, we will focus first on the variable of knowledge integration, one of the most important organizational capabilities. Grant (1996) identifies knowledge integration as "the organizational capability" and proposes a complete theory of the firm based on organizational knowledge integration capacity. Knowledge integration can be defined as "an ongoing collective process of constructing, articulating and redefining shared beliefs through the social interaction of organizational members" (Huang, 2000, p.15).

In attempting to describe the knowledge integration process, the literature has identified different antecedents for achieving knowledge integration. Of these antecedents, teamwork is one of the most important facilitators of knowledge integration. Centralization is not a good mechanism, as not all necessary knowledge can be integrated in the manager's head. Team structure is a more communicative and more personal coordination option. Teamwork facilitates knowledge interchange between specialists, contributing to better solutions and new knowledge development (Becker and Zirpoli, 2003; Grant, 1996; Hislop, 2003; Molina, Llorens and Ruiz, 2006). It is important to clarify that knowledge integration not only consists of knowledge sharing but also leads to obtaining new knowledge, since individuals combine the information they possess (Okhuysen and Eisenhardt, 2002). Recent literature provides empirical support for obtaining effective knowledge integration with team structure (Enberg, 2012; Singh, 2008). The study of Okhuysen and Eisenhardt (2002) is especially important, as it observes that using three formal interventions in teams–information sharing, questioning others, and managing time, that is, knowledge integration—takes place in these teams. Autonomy and experimental climates are also directly related to knowledge integration (Basaglia, Caporarello, Magni and Pennarola, 2010). In conclusion, the literature supports that teamwork facilitates knowledge integration.

Six Sigma teamwork provides a good opportunity to improve the knowledge integration process. One of the distinctive aspects of Six Sigma teamwork is its role structure (Brun, 2011; Zu et al., 2008). Positions like "Champions" or "Black Belts" constitute a specific contribution of this methodology, which assigns leadership roles and responsibilities in improvement teams (Brun, 2011; Schroeder et al., 2008; Zu et al., 2008). For example, "Black Belts" are responsible for putting projects into action, providing training, and (especially important for our study) leading team members. Six Sigma-team managers should try to make the most of their team members to enable teams to achieve the most beneficial solutions for the organization. To this end, Six Sigma-team managers are trained to use a wide range of tools and techniques to increase team members' involvement (Anand et al., 2010; Breyfogle, 2003; Pande et al., 2000), and this methodology has a whole infrastructure to increase participation of team members.

The literature argues that Six Sigma teamwork per se could contribute to knowledge integration. This contribution is due, however, to more effective mechanisms included in Six Sigma teams that promote the exchange of opinions, discussions, and idea sharing (Anand et al., 2010; DeMast, 2006; Mellat, 2011). These tools and techniques and team managers' leadership role facilitate the exchange of information and shared beliefs and create social interaction between organizational members, as Huang (2000) demonstrates. We can thus establish the next hypothesis:

H2: Six Sigma team management practice is positively related to the knowledge integration process.

Knowledge transfer is defined as "the process through which one unit (e.g., group, department, or division) is affected by the experience of another" (Argote and Ingram, 2000, p.151). Previously, Szulanski (1996) defined best practice transfers as "a dyadic exchanges of organizational knowledge between a source and a recipient unit, in which the identity of the recipient matters" (Szulanski, 1996, p.28). In this research, we focus on subsidiary firms and the knowledge transfer that occurs between subsidiary firms and the parent corporation and sister subsidiaries.

Knowledge transfers require a certain level of knowledge from the members involved in the sharing process (Burns, Acar and Datta, 2011). Integrated knowledge "create[s] a common base on which to transfer knowledge" (Molina et al., 2006, p.685), and integrated relationships facilitate information exchange (Cheung, Myers and Mentzer, 2011). Teamwork provides opportunities to share common images, experiences, identities, etc., which contribute to knowledge transfer (Brown and Duguid, 2001; Crossan, Lane and White, 1999; Dougherty, 2001; Molina et al., 2006). Six Sigma team management thus facilitates the entire infrastructure for sharing images, common experiences, etc., creating, what we have called the knowledge integration process. For example, Gutierrez et al. (2009) empirically test the positive relationship between Six Sigma teamwork and shared-vision development. On the other hand, since integrated knowledge is shared by team members, it is more explicit, or at least less tacit, than individual knowledge. Moore and Birkenshaw (1998) propose that integrative tools such as centralized databases facilitate knowledge transfer, reducing the complexity and tacitness of the knowledge and facilitating future knowledge transfer (Winter, 1987; Zander and Kogut, 1995). As a result, we propose the following hypothesis:

H3: The knowledge integration process is positively related to knowledge transfers in Six Sigma firms.

3. Research design and methodology

3.1. Sample selection, description, and research instrument

The sample used in this research comes from a larger study that analyzes QM implementation in European firms. Our study aims to observe the behavior of different quality management initiatives, such as ISO standards, the EFQM model, TQM, and Six Sigma. For the original study, we randomly selected a list of 2500 manufacturing and service firms in Europe, using the Amadeus database and the publication *Actualidad Económica* (2004). After we selected this target sample, data collection consisted of sending an email letter to the QM managers in each firm. The letter included an explanation of the importance of the research and its main goals, and the email included

a direct link to a web page where the managers could fill out a questionnaire and send it automatically and anonymously.

The questionnaire contained questions related to the implementation of QM initiatives, QM practices, knowledge management, and performance. The questionnaire was developed after a detailed analysis of literature on QM and organizational capabilities related to knowledge management. The completed questionnaire was pre-tested by three QM managers to avoid possible mistakes, ambiguities, or formatting errors.

To obtain the sample for this study, we used the following process. As mentioned above, the original target sample was composed of 2500 European firms. From these firms, we obtained 254 responses, a response rate of 10.16%. Seventeen responses were eliminated because they contained mistakes or were incomplete, leaving a final sample of 237 valid responses from the original study. We analyzed possible bias (Amstrong and Overton, 1977) and found no significant differences between early and late respondents on organizational variables.

As the goal of this research is to analyze Six Sigma transnational firms, we applied a double filter to the previous 237-firm sample. Firstly, and specifically for this research, these firms should have a parent company and sister subsidiaries to transfer knowledge between them. After elimination of firms that did not fulfill this requirement, 174 firms remained. Of these 174 firms, we differentiated between companies that had implemented Six Sigma and those that had not and found that 121 firms were not involved in Six Sigma. Our final sample was thus composed of 53 Six Sigma subsidiary firms.

The final sample had the following characteristics. Of the 53 Six Sigma subsidiaries, 32.07% had from 51 to 250 employees, 41.51% from 251 to 1000, and 26.41% had over 1000. As to activity sector, 39.62% of the firms belonged to the machinery and components sectors, 32.07% to the service sector, 15.10% to electronics and electricity, and the remaining 13.20% to miscellaneous sectors. Finally, as to the country of origin, most of the organizations were based in Spain (64.15%). The rest of the sample was distributed among Italy (15.10%), the United Kingdom (9.43%), Austria (7.54%), Sweden (1.89%), and Switzerland (1.89%). As all of these firms are subsidiaries, however, they form part of larger organizational structures that normally--although not necessarily—operate internationally. This characteristic reduces the importance of the information on original country. Now that we have described our sample, we will analyze the measurement scales used.

3.2.Variable measurement

To measure variables included in this research, we analyzed the literature related to them and selected the items most appropriate for our purpose. All scales were accompanied by a 7-point Likert-type scale (1=totally disagree; 7=totally agree). Firstly, to measure the variable team management, we used part of the original scale from Flynn, Schroeder and Sakakibara (1995), which measured teamwork in a QM context. Secondly, for the knowledge integration variable, we included a five-item scale based on Grant (1996). Finally, for knowledge transfer, the questionnaire included the four-item scale from Gupta and Govindarajan (2000), in which the authors observe that the subsidiaries provide and receive knowledge and skills to and from sister subsidiaries and parent corporations. All items are included in Table 1. To measure Six Sigma implementation, the questionnaire included a list of QM initiatives such as ISO standards, TQM, EFQM

model and Six Sigma, with a 7-point Likert scale, where 1 signified minimal implementation and 7 maximum implementation. All scales were subjected to the validation process described in the next section.

4. Results

4.1.Scale validation process

To ensure accurate good analysis of the data, we ran a validation process for the scales. Firstly, through an exploratory factor analysis, we tested whether all scales explained a single factor and consequently fulfilled the requirement of unidimensionality. Secondly, we analyzed internal consistency by observing the Cronbach's alpha. The results are included in Table 1. All Cronbach's alpha values were higher than the minimum recommended value (0.7), confirming the internal consistency of the scales. For these last two tests, we used SPSS 22.0 software. Once the unidimensionalty and internal consistency of the scales were guaranteed, we ran a confirmatory factor analysis using the EQS 6.2 software to determine the validity of the scales. All factor loadings on the items should be significant (t-value>1.96, $p<0.05$) and have an individual reliability (R^2) that exceeds 0.5. Based on these results, some items were removed from the analysis—the first three items of the knowledge integration scale and the last two items of the knowledge transfer scale. The final items fulfill all requirements to ensure the convergent validity of the scales (see Table 1). The items remaining after the validation process were used in subsequent analyses.

Insert Table 1 about here

4.2.ANOVA analysis

The first hypothesis establishes that team management in Six Sigma subsidiary firms is statistically different from team management in subsidiary firms that implement other QM initiatives. To test this hypothesis, we ran an ANOVA analysis using SPSS 20.0 software. As mentioned in Section 3.1, there were 174 subsidiary firms in the original sample. Because 53 of these 174 firms were Six Sigma firms, we divided the sample into two groups. The first group was composed of subsidiary firms that had implemented Six Sigma (n=53). The second group was composed of subsidiary firms that had implemented other QM initiatives, such as ISO standards, the EFQM model, Quality Control, or TQM (n=121)[2]. Next, we ran the ANOVA test on the two groups for the variable team management. The results obtained are presented in Table 2. They show a significant difference between the groups, leading us to accept Hypothesis 1.

Insert Table 2 about here

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[2] To ensure the homogeneity of variances between the two groups, we run Levene's test. For a 5% significance level, result shows that we cannot reject the hypothesis of homogeneity of variances (Statistic value=3.294, p-value=.071).

4.3.Structural Model

To contrast the remaining hypotheses, we used the partial least squares (PLS) approach to structural equation modeling (SEM). Smart PLS software was used for the analysis. Traditional covariance-based SEM approaches using LISREL or EQS require a significant sample size to fulfill the power requirements (Bagozzi and Yi, 2012; Chin, Marcolin and Newsted, 2003). Although our sample size is not large enough to use these approaches, PLS is especially suitable for studies with small sample size (Benitez-Amado and Walczuch, 2012; Chin et al., 2003) and consequently more appropriate for our study. Operations management journals have recently incorporated this approach in their publications (Lockstrom and Lei, 2013; Mackelprang, Jayaram and Xu, 2012; Perols, Zimmermann and Kortmann, 2013; Sawhney, 2013).

Mackelprang et al. (2012) give a detailed explanation of PLS usage in cases of operations management publications. According to these authors, PLS tests simultaneously model parameters and structural paths using the least squares method instead of covariance-based SEM approaches that employ maximum likelihood estimation (Wold, 1985). "PLS focuses on the strength of the individual component relationships rather than the overall fit of the proposed model to observed covariances amongst all the variables" (Mackelprang et al., 2012, p.189). Unlike covariance-based SEM approaches that require large sample size and multivariate normal data distribution, PLS is suitable for small data sets, since this approach avoids factor indeterminacy and inadmissible solutions (Chin et al., 2003).

PSL requires that the sample size or minimum number of cases satisfy the heuristic condition of being at least ten times larger than the largest number of structural paths to any construct (Mackelprang et al., 2012). In our case, this condition is satisfied, as our sample consists of 53 observations, greater than the required minimum amount.

To evaluate PLS models, it is first necessary to evaluate the measurement model. To do this, we measure internal reliability, convergent validity, and discriminant validity (Hulland, 1999; Nunally, 1978). To establish internal reliability, composite reliability and the Cronbach's alpha must be larger than 0.70. In our model, all values satisfy both requirements (see Table 1), ensuring internal reliability. For convergent validity, factor loadings must be significant (loadings greater than 0.7, significant t-value, and R^2>.5), and Average Variance Extracted (AVE) must be larger than 0.5. Table 1 collects the values obtained that show the convergent validity of the measurement model. Finally, to test discriminant validity, we follow Szulanski (1996) in estimating a calculated correlation as the product of composite reliability among the variables. To ensure discriminant validity, values of calculated correlation must be higher than values of estimated correlation (see Table 3). As observed, all values indicate that the measurement model is suitable for estimation.

Insert Table 3 about here

After the psychometric properties of internal reliability, convergent validity, and discriminant validity were tested, we evaluated the structural model. To evaluate the relationships between variables, we observed the path coefficients for the overall model.

Firstly, the results show a positive and significant relationship between team management and knowledge integration (λ=.518***; t=9.415). This result allows us to accept Hypothesis 2. Secondly, the results show a positive and significant relationship between knowledge integration and knowledge transfer (λ=.382***; t=6.391), leading to the acceptance of Hypothesis 3. All relationships are significant at a level of 0.001 (t-value>3.291).

5. Discussion

The main purpose of this paper was to test the relationship between Six Sigma implementation and the knowledge transfer process. For this purpose, we first observed how team management practice in Six Sigma firms differs from team management practices implemented in firms with other QM initiatives. As mentioned in Section 2, the theoretical literature supports the conclusion that one of the distinctive aspects of Six Sigma is its role structure and team management (Schroeder et al., 2008; Zu et al., 2008). This study is the first to test empirically the difference in team management between Six Sigma firms and other QM firms. The results show that degree of team management implementation is statistically higher in Six Sigma firms. Six Sigma team managers significantly facilitate exchange of ideas, promote employee participation, and create a good environment for teamwork. Consequently, we can affirm that Six Sigma is an initiative that promotes a philosophy of teamwork at a higher level than other QM initiatives. Such an initiative could contribute important benefits to organizations. As shown below, teamwork is related to knowledge management variables, although the traditional literature also relates teamwork to other relevant variables, such as higher employee morale, better decisions and greater acceptance of decisions (Detert, Schroeder and Mauriel, 2000; Llorens and Molina, 2006), and win-win relationships between managers and employees (Anderson, Rungtusanatham and Schroeder, 1994). As a result, Six Sigma teamwork could establish greater organizational improvements than other QM initiatives.

These conclusions concerning the higher level of Six Sigma team management do not mean that organizations should replace traditional QM initiatives with Six Sigma. As Zu et al. (2008) demonstrate, Six Sigma practices can enhance existing QM systems. All practices can work together to improve quality performance and organizational success. We propose that previous experience in QM teamwork could benefit subsequent implementation of Six Sigma teamwork, since some technical aspects of Six Sigma team management are complex. Six Sigma thus constitutes a next step in QM implementation that can benefit from all previous achievements in this field.

Secondly, we observe a significant relationship between Six Sigma team management and knowledge integration. Formal improvement processes facilitate knowledge creation in Six Sigma (Linderman et al. 2003), and team managers play a fundamental role in guiding all of these processes in project teams. The resulting integration mitigates potential problems that can hinder Six Sigma success, such as lack of coordination or short closure of project teams (Gijo and Rao, 2005).

Thirdly, results demonstrate a positive relationship between knowledge integration and knowledge transfer in Six Sigma firms. The theoretical justification for this relationship lies in the idea of creating a common base to transfer knowledge, as Six Sigma does, through common images, experiences, or shared vision (Gutierrez et al.,

2009). The integrated common knowledge base in Six Sigma teams is an incredibly valuable capacity. Sharing aspects of culture, experiences, values, image, or vision can generate added value, rareness, non-substitutability, and difficulty of imitation. It thus represents a potential source of competitive advantage. Further, the transfers performed disseminate knowledge that contributes to the previous common knowledge base, creating a recurrent cycle between knowledge transfer and integrated knowledge.

The knowledge transfer process facilitates effective utilization of knowledge, as knowledge can flow among units and be utilized where necessary. Subsidiaries of the same company probably have similar processes. Even where team projects were run inside a subsidiary, the solutions found could be useful in other subsidiaries and should be provided to them. The knowledge transference process will increase the company's learning capacity and that of its subsidiaries (Chen, McQueen and Sun, 2013; Schmickl and Kieser, 2008), in turn increasing the ability to develop better adaptation capabilities and improving the competitive position of the firm (Gowen and Tallon, 2005; Swink and Jacobs, 2012).

Swink and Jacobs (2012) question whether Six Sigma could benefit some capabilities and harm others at the same time, as occurs with other instances of process improvement that do not contribute to innovative exploration while favoring exploitation (Benner and Tushman, 2003; Naveh and Erez, 2004). However, we agree with literature that affirms that Six Sigma does not harm an innovative orientation (Mellat, 2011; Schroeder et al., 2008). Our results are consistent with this vision, as knowledge transference capacity is related to product and service innovation (Mei and Nie, 2007; Subramaniam and Youndt, 2005).

Finally, our paper contributes to studies that highlight the importance of cultural issues in Six Sigma implementation (Hilton and Sohal, 2012; Huq, 2006; Mellat, 2011; Zu, Robbins and Fredendall, 2010; Swink and Jacobs, 2012). Our paper shows the fundamental role of the team managers who lead the improvement projects, enhancing a culture that tries, firstly, to eliminate fear or coercion for employees, and, secondly, to increase collaboration and involvement (Zu et al., 2010). The cultural change associated with Six Sigma implementation, which leads to common language, shared vision, etc. (Gutierrez et al., 2009), could also constitute a specific feature of this methodology (Mellat, 2011). As mentioned above, this feature can provide a good opportunity for obtaining competitive advantage.

Concerning practical implications for managers, our paper offers three main contributions. Firstly, managers should consider the relevant role that team managers play in the Six Sigma organizational success. Providing resources (training, time, funds, etc.) is an investment that can contribute positively to firms. Secondly, for organizations that lack knowledge transfer and integration, Six Sigma implementation can provide a good alternative to stimulate this process. The philosophy behind this methodology helps to create a common knowledge base that will benefit the organization. Thirdly, managers should consider the cultural issues related to Six Sigma implementation as an important requirement for its success. The positive effects of team management culture and of shared culture among firm members are significant. These benefits could require a significant effort, however, since cultural changes are difficult to achieve and may raise internal objections. In sum, this paper gives a solid explanation for deciding to implement Six Sigma, especially in companies that have a structure of parent corporation and sister subsidiaries.

6. Conclusion, limitations, and lines for further research

This paper has described a global process that explains the knowledge transfer process in Six Sigma subsidiary firms as it is enhanced by team management. The results show Six Sigma to be a QM initiative that implements team management at higher level. Six Sigma also facilitates the creation of a common base of integrated knowledge, contributing to a knowledge transfer process that influences organizational success positively.

Our interpretation of these results is limited for several reasons. Firstly, Six Sigma implementation is measured using a categorical variable. More detailed information on the degree of Six Sigma implementation would have enabled a more complete interpretation. Secondly, validation of the scales led to elimination of two items from the knowledge transfer scale. The resulting items only observe how subsidiaries provide knowledge to the parent corporation and sister subsidiaries, not how they receive it. Further, a single respondent and the cross-sectional character of the research limit interpretation of the results.

Finally, we consider several lines for further research. First, cultural change associated with Six Sigma implementation constitutes an important gap that may explain some distinctive aspects of this methodology. Secondly, longitudinal analysis would improve understanding of Six Sigma's long-term benefits. Thirdly, further analysis of exploratory variables could add significantly to the current debate on Six Sigma's ambidexterity. These lines of research could contribute to a deeper understanding of the Six Sigma initiative, providing accurate explanations and recommendations for organizations. Finally, further research could observe if our conclusions are exclusive of Six Sigma methodology or if they can be extrapolated to firms that implement similar improvement initiatives, such as Lean Six Sigma.

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Table 1. Scales items and validation

Items	Mean	S.D.	Standardized factor loadings (>0.4[a]; t>1.96 [a])	R^2 (>0.5[a])	Composite reliability	AVE	Cronbach's Alpha (>0.7[b])
Team management					.9313	.8189	.882
1. Supervisors encourage the persons who work for them to exchange opinions and ideas.	5.36	1.210	.880 (t=49.465)	.774			
2. Supervisors encourage the people who work for them to work as a team.	5.34	1.208	.900 (t=53.121)	.810			
3. Supervisors frequently hold groups meetings where the people who work for them can really discuss things together.	5.00	1.581	.934 (t=153.876)	.872			
Knowledge integration					.8999	.8181	.777
1. The rules/policies of the firm enabled the co-ordination of activities and information flows.	5.38	1.023	-	-			
2. The firm had production activities divided into independent phases and organized sequentially	5.47	1.552	-	-			
3. There were generally accepted behaviour patterns that governed actions when rules and procedures did not.	5.47	1.012	-	-			
4. The organization resolved uncertainty through conflict resolution and decision-making groups.	5.45	1.338	.905 (t=54.358)	.819			
5. The rules, sequences, behaviours patterns and groups enabled sharing the useful knowledge among members of the firm, avoiding unnecessary transfers.	5.00	1.240	.904 (t=45.894)	.817			
Knowledge transference					.9241	.8591	.840
1. Provides knowledge and skills to sister subsidiaries.	5.30	1.265	.954 (t=93.739)	.910			
2. Provides knowledge and skills to parent corporation.	4.81	1.401	.899 (t=30.625)	.808			
3. Receives knowledge and skills from sister subsidiaries.	5.13	1.665	-	-			
4. Receives knowledge and skills from parent corporation.	5.28	1.498	-	-			

[a] Hulland (1999)

[b] Nunally (1978)

Table 2. ANOVA analysis

Group	n	Mean	S.D.	F	Significance level
Group 1: Team management in Six Sigma subsidiaries firms	53	5.2327	1.20997	5.126**	.025
Group 2: Team management in Non-Six Sigma subsidiaries firms	121	4.6722	1.61359		

Table 3. Discriminant validity

Variable	1	2	3
1. Team management	-	.838	.860
2. Knowledge integration	.518	-	.831
3. Knowledge transference	.496	.367	-

Upper quadrant: Calculated correlation. Lower quadrant: Observed correlation