



HAL
open science

Six Sigma, absorptive capacity and organizational learning orientation

Leopoldo J Gutiérrez Gutiérrez, Oscar F Bustinza Sánchez, Vanesa Barrales Molina

► **To cite this version:**

Leopoldo J Gutiérrez Gutiérrez, Oscar F Bustinza Sánchez, Vanesa Barrales Molina. Six Sigma, absorptive capacity and organizational learning orientation. *International Journal of Production Research*, 2011, pp.1. 10.1080/00207543.2010.543175 . hal-00708536

HAL Id: hal-00708536

<https://hal.science/hal-00708536v1>

Submitted on 15 Jun 2012

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Six Sigma, absorptive capacity and organizational learning orientation

Journal:	<i>International Journal of Production Research</i>
Manuscript ID:	TPRS-2010-IJPR-0701.R1
Manuscript Type:	Original Manuscript
Date Submitted by the Author:	04-Oct-2010
Complete List of Authors:	Gutiérrez Gutiérrez, Leopoldo; University of Granada, Business Administration Bustanza Sánchez, Oscar; University of Granada, Business Administration Barrales Molina, Vanesa; University of Granada, Business Administration
Keywords:	SIX SIGMA, TEAMWORK, PROCESSES, LEARNING, KNOWLEDGE MANAGEMENT
Keywords (user):	Absorptive Capacity, Organizational Learning Orientation

SCHOLARONE™
Manuscripts

Title

Six Sigma, absorptive capacity and organizational learning orientation

Authors

L.J. Gutiérrez Gutiérrez^a, O.F. Bustinza Sánchez^a and B. Barrales Molina^a

^aDepartment of Business Administration.

Cartuja s/n, 18071.

University of Granada.

Granada; Spain

Corresponding author

L.J. Gutiérrez Gutiérrez

Email: leogg@ugr.es

Phone: +34 667343073

Fax: +34 958246222

Department of Business Administration.

Cartuja s/n, 18071.

University of Granada.

Granada; Spain

Six Sigma, absorptive capacity and organizational learning orientation

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 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

1
2 performance. This paper contributes to the empirical literature on Six Sigma by
3
4 observing its positive effects on organizational performance, through the observation of
5
6 absorptive capacity and organizational learning orientation. Specifically, our study finds
7
8 that teamwork and process management are important Six Sigma practices and tests
9
10 whether they could be a reason for the initiative's success.
11

12
13
14 Recently, Schroeder et al. (2008) published a theoretical analysis of Six Sigma
15
16 methodology. In this study, Schroeder et al. (2008) identify research issues for future
17
18 study. One of these issues is based on the fact that "Six Sigma is an organizational
19
20 learning process and one that results in greater knowledge" (Schroeder et al., 2008,
21
22 p.549). As a consequence, "viewing Six Sigma through the lens of knowledge
23
24 management and organizational learning can lead to insights about how to create, retain,
25
26 and diffuse knowledge using a structured method" (Choo et al., 2007; Lapré et al.,
27
28 2000). Other recent studies have indicated the importance of pursuing this issue in the
29
30 study of Six Sigma. For example, Linderman et al. (2003; 2006) argue that it would be
31
32 interesting to consider Six Sigma from the perspective of knowledge management.
33
34 Lloréns et al. (2006) propose studying how Six Sigma practices create a good learning
35
36 climate. Choo et al. (2007) indicate the lack of studies that analyze how the technical
37
38 and social components of QM practices, and specifically those of Six Sigma, lead to
39
40 learning and knowledge creation. We therefore orient our study to all of these proposed
41
42 lines of research and attempt to study the effects of the Six Sigma methodology on
43
44 knowledge absorptive capacity and its effect on organizational learning orientation.
45
46

47
48 Organizational learning constitutes one of the sources of competitive advantage for
49
50 organizations (Huber, 1996; Rindova and Fombrun, 1999; Senge, 1990; Tu et al., 2006).
51
52
53
54
55
56
57
58
59
60

1
2 Positive effects of learning orientation on organizational performance have been tested
3
4 (Calantone et al., 2002; Tien and Hsin, 2005; Zahra et al., 2000). Absorptive capacity
5
6 plays a crucial role in the search for knowledge. As a result, absorptive capacity has
7
8 been one of the most studied aspects of knowledge management in recent years (Fosfuri
9
10 and Tribó, 2008; Jansen et al., 2005; Lane et al., 2006; Lichtenthaler, 2009; Todorova
11
12 and Durisin, 2007; Tu et al., 2006). “Absorptive capacity is one of the constructs to
13
14 emerge in organizational research in recent decades” (Lane et al., 2006, p.833). The
15
16 current turbulent dynamic environments have made absorptive capacity one of the most
17
18 important dynamic capacities in generating sustainable competitive advantage (Fosfuri
19
20 and Tribó, 2008; Lenox and King, 2004; Tu et al., 2006; Zahra and George, 2002). Our
21
22 study seeks to enrich this line of research by observing whether we can go beyond our
23
24 knowledge that teamwork and process management of the Six Sigma methodology
25
26 affect absorptive capacity to determine whether absorptive capacity can be related to
27
28 organizational learning orientation.
29

30
31
32 The main purpose of this paper is to determine whether Six Sigma teamwork and
33
34 process management have a positive influence on the development of absorptive
35
36 capacity. We will then determine whether this absorptive capacity is related to
37
38 organizational learning orientation. The paper is structured as follows: After this
39
40 introduction, we present a literature review that covers three areas: Six Sigma
41
42 methodology and its teamwork and process management; the importance of absorptive
43
44 capacity in the organization; and the relationships between teamwork and process
45
46 management in Six Sigma and absorptive capacity, and the relationship between
47
48 absorptive capacity and organizational learning orientation in Six Sigma firms. After we
49
50 review the literature, we describe the methodology and the analysis performed.
51
52
53
54
55
56
57
58
59
60

1
2 Subsequently, we discuss the results obtained and present the main conclusions,
3
4 limitations and recommended directions for future research.
5
6
7

8 **2. Theoretical background**

9 *2.1. The Six Sigma Methodology: Teamwork and Process Management*

10
11 Six Sigma is defined as “an organized, parallel-meso structure to reduce variation in
12
13 organizational processes by using improvement specialists, a structured method, and
14
15 performance metrics with the aim of achieving strategic objectives” (Schroeder et al.,
16
17 2008, p.540). Six Sigma is a method for improving organizational processes that goes
18
19 beyond quality assurance or quality control (Harry, 2000). In fact, based on the
20
21 literature review and considering Six Sigma as a management philosophy, this
22
23 methodology is similar to the concept of Total Quality Management (TQM) (Cheng
24
25 2009; Green, 2006; Lloréns et al., 2006; Lucas, 2002; Van Iwaarden et al., 2008).
26
27
28
29

30
31 Teamwork is one of the pillars of Six Sigma methodology (Breyfogle, 2003; Lloréns et
32
33 al., 2006; Lowenthal, 2002; Pande et al., 2002). Continuous improvement proposed by
34
35 this philosophy is developed through different projects assigned to teams of workers.
36
37 The success of improvement projects depends on these cross-functional teams (Pande et
38
39 al., 2002; Shamji, 2005). Teamwork is the key factor for Six Sigma success, due to the
40
41 fact that team members are the main carriers of the new philosophy (Thawani, 2004). In
42
43 one year, General Electric invested \$450 million in six improvement projects, obtaining
44
45 benefits near \$1.2 billion (Lucas, 2002). Shamji (2005) collected several firm
46
47 experiences including those of Samsung Electronics, American Express and DuPont and
48
49 found that the savings derived from each Six Sigma improvement project ranged from
50
51 \$100,000 to \$200,000.
52
53
54
55
56
57
58
59
60

1
2
3
4 The main difference between Six Sigma teamwork and the teamwork in other quality
5 management initiatives is that Six Sigma creates specialized positions, carried by
6 employees, to run its projects instead of overloading the firm's managers (Lloréns et al.,
7
8
9
10 2006). These specialized positions constitute a structure of roles that is one of Six
11 Sigma distinguishing aspects (Zu et al., 2008). Positions such as "Champions", "Master
12 Black Belts", "Black Belts" and "Green Belts" are explicitly established (Sinha and Van
13 de Ven, 2005). According to Gitlow (2005) and Pande et al. (2002), "Champions" are
14 usually members of the Executive Committee. They facilitate the obtaining of resources
15 and elimination of barriers for the development of improvement projects. "Champions"
16 usually sponsor these specific projects. "Master Black Belts" play a role as Six Sigma
17 process leaders, linking top management to the main person responsible for an
18 improvement project. They have developed important abilities and possess deep
19 knowledge of Six Sigma methodology. "Black Belts" are full-time agents dedicated to
20 an improvement project. They are posted to specific projects to be in charge of such
21 activities as putting the project into action, training members, and providing leadership.
22 "Green Belts" are workers who belong to an improvement project or lead a team but
23 have only part-time dedication to this task.
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39

40 On the other hand, Six Sigma is clearly oriented to strategic process improvement
41 (Linderman et al., 2003; Schroeder et al., 2008; Zu et al., 2008). Six Sigma practitioners
42 "identify and clarify the core processes whose improvement will yield the most
43 dramatic changes and benefits for customers and the organization" (Lloréns et al., 2006,
44 p.487). Process management orientation to continuous improvement requires that Six
45 Sigma members are trained intensely in abilities, group dynamics and statistical
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2 methods and tools (Gitlow, 2005; Lee et al., 2006; Ravichandran, 2006; Zu et al., 2008).
3
4 For example, the DMAIC cycle (define, measure, analyze, improve and control) is also
5
6 present in Six Sigma, as a tool for process improvement (Kanji, 2008; Kaushik and
7
8 Khanduja, 2009; Schroeder et al., 2008). Besides, Breyfogle (2003) describes a very
9
10 wide variety of statistical tools that can be used in each phase of the DMAIC cycle.
11
12 Examples of these tools include scorecards, Pareto diagrams, cause-effect diagrams,
13
14 benchmarking, brainstorming, histograms, quality function deployment (QFD), control
15
16 charts, comparison tests, regression analysis and many others. Kanji (2008) adds other
17
18 known practices that Six Sigma can incorporate, such as Poka-Yoke, Kaizen, Kanban
19
20 and Lean Manufacturing. Thus, when positions and roles have been assigned and tools
21
22 and abilities developed, teams begin the work that focuses on defect rate reduction in
23
24 each improvement project selected. Teams design successful solutions and show that
25
26 the tools and abilities learned work well (Cooper, 2003).
27
28
29

30 In this way, Six Sigma process management requires very solid statistical
31
32 methodologies of experimentation and research (De Mast, 2006; Kanji, 2008). Lloréns
33
34 et al. (2006) present Six Sigma as the strongest technique for quality improvement from
35
36 the statistical perspective. In fact, the definition given by Linderman et al. (2003)
37
38 indicates how this initiative describes a process management that is grounded in
39
40 statistical methods. Thus, it can be concluded that the Six Sigma method for process
41
42 improvement requires an intensive training of the full-time specialists, and the full
43
44 integration of statistical and non-statistical tools, which are unique (Schroeder et al.,
45
46 2008). Therefore, another distinctive aspect of the Six Sigma methodology, in addition
47
48 to teamwork, is the importance given to process management.
49
50
51
52
53
54
55
56
57
58
59
60

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

1
2 from external sources, (3) *transformation*, which combines existing and the new,
3 acquired and assimilated knowledge, and (4) *exploitation*, which is based on routines
4 that facilitate improvement, expansion, and influence on existing capacities or the
5 creation of new ones, thanks to the knowledge acquired and transformed.
6
7
8
9

10 11 12 2.3. *Six Sigma teamwork, process management and absorptive capacity*

13
14 We will now analyze how teamwork and process management included in Six Sigma
15 methodology can affect absorptive capacity, through four arguments. Firstly, various
16 studies have remarked that using mechanisms to integrate workers has a positive effect
17 on absorptive capacity (Cohen and Levinthal, 1990; Lane et al., 2006; Todorova and
18 Durisin, 2007; Van den Bosch et al., 1999; Zahra and George, 2002). Jansen et al.
19 (2005) study whether cross-functional interfaces, such as teamwork, are positively
20 related to the four dimensions of absorptive capacity identified by Zahra and George
21 (2002). Jansen et al. (2005) affirm that systems such as teams use lateral
22 communications mechanisms, which facilitate knowledge flow through functional
23 borders, enabling connection between different sources and increasing the interaction
24 between areas. This enhanced communication should contribute to the first two phases,
25 that of knowledge acquisition and assimilation. Further, these interfaces permit
26 employees to combine existing and recently acquired knowledge. According to authors
27 like Cohen and Levinthal (1990) and Daft and Lengel (1986), cross-functional
28 interfaces help to integrate the different bodies of knowledge and to create routines
29 within the units. These aspects will contribute to the transformation and exploitation of
30 knowledge, the last two phases in absorptive capacity. Results show a positive relation
31 between cross-functional interfaces and the four phases proposed by Zahra and George
32 (2002), although this relationship is only significant in the case of the first three.
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4 The QM literature has shown how Quality Management teamwork encourages workers
5 to share expert knowledge related to their immediate work tasks and to use their creative
6 abilities to suggest new ways to improve (Cole et al., 1993; Chiles and Choi, 2000;
7 Silos, 1999), a clear example of the kind of team Jansen et al. (2005) observed. As
8 stated above, teamwork constitutes one of the main aspects of Six Sigma methodology
9 (Breyfogle, 2003; Lloréns et al., 2006; Lowenthal, 2002; Pande et al., 2002). Six Sigma
10 attempts to decrease the number of defects that appear in different organizational
11 processes and to use cross-functional teams who, through communication mechanisms,
12 strengthen the relationship between different areas of functioning and stimulate
13 knowledge absorption. For example, Park et al. (2009) argue that the activities
14 performed by Six Sigma teams enable the creation and capturing of information, the
15 storing and sharing of information, and the use of information in the DMAIC cycle.
16 Thus, Six Sigma teamwork has a series of characteristics in common with the teams
17 studied by Jansen et al. (2005), characteristics that affect absorptive capacity positively.
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33

34 Secondly, Six Sigma teamwork is distinguished by the creation of specialized positions
35 (Lloréns et al., 2006; Zu et al., 2008). Those who hold positions such as “Champion”,
36 “Master Black Belt”, and “Black Belt” play the role of leaders (Choo et al., 2007),
37 creating recognition of the need and fostering the collective desire to learn (Senge 1999,
38 p.38, in Choo et al., 2007), thus guiding the learning efforts (Choo et al., 2007; Wiklund
39 and Wiklund, 2002). Through the formation and creation of these specialized positions,
40 Six Sigma permits the development and better use of existing knowledge in the
41 organization (DeMast, 2006). Leadership should promote the most beneficial learning
42 by indicating how efforts to absorb knowledge should be conducted and by playing a
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2 helpful role in facilitating these efforts. Leadership should guide and direct the efforts to
3 absorb knowledge and can constitute an important aid in achieving this absorption,
4 yielding advantageous learning as a result.
5
6
7

8
9
10 Further, in Six Sigma, people who hold these specialized positions have all the time
11 they need to spend on the Six Sigma projects and thus are a very important resource
12 devoted to problem solving (Choo et al., 2007). Knowledge absorption plays a key role
13 in problem solving. The availability of human resources dedicated to problem solving,
14 among other tasks, has a very positive effect, since as Choo et al. (2007) argue, the
15 availability of resources constitutes a crucial antecedent for achieving knowledge
16 creation and learning.
17
18
19
20
21
22
23
24
25

26 Thirdly, as Gupta and Govindarajan (2000) argue, another important antecedent of
27 absorptive capacity is the degree of similarity between the work units in matters of
28 language, culture, etc. These authors study what they call “homophily”, which they
29 define as “the degree to which two or more individuals who interact are similar in
30 certain attributes” (Rogers, 1995, pp.18-19). Sharing beliefs, language and even
31 personal characteristics facilitates communication and thus the absorption of new
32 knowledge. On observing this issue in Six Sigma, Gutierrez et al. (2009) conducted a
33 study in which they demonstrate empirically that Six Sigma teamwork facilitates the
34 development of a shared vision among team members. Shared vision facilitates a greater
35 similarity between the receiving and the sending unit, achieving the “homophily”
36 proposed by Gupta and Govindarajan (2000), thus having positive repercussions for
37 absorptive capacity.
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

1
2 performance means that companies receive knowledge about these processes (Wiklund
3 et al., 2002). Thus, the methodological elements proposed by Choo et al. (2007)
4 stimulate the development of frequent communication, which in turn increases the
5 amount of information available. Further, these elements allow existing efforts to be
6 coordinated and aligned, individual perspectives to be integrated and problems to be
7 better understood. All of this makes it easier for members of the organization to absorb
8 new knowledge.
9

10 We also wish to mention the importance of one characteristic of process management.
11 Regarding the stages of acquisition and transformation of absorptive capacity, we find
12 that management of processes acts as a source of information about the processes on
13 which employees work (Flynn et al., 1995; Saraph et al., 1989). Thus, one of the most
14 important factors influencing the success of the absorption process is the existence of
15 prior knowledge related to the new knowledge that will be absorbed (Cohen and
16 Levinthal, 1990; Gupta and Govindarajan, 2000; Todorova and Durisin, 2007; Tu et al.,
17 2006; Van den Bosch et al., 1999; Zahra and George, 2002). This knowledge facilitates
18 learning, as memory helps to establish relationships between new and existing concepts.
19 Knowledge of the process is one of the requirements proposed by Oakland (1989) for
20 achieving continuous improvement in QM. To satisfy this requirement, managing
21 processes and controlling them statistically generates and stores information on the
22 functioning of organizational processes in order subsequently to improve them (Mason
23 and Antony, 2001; Rungtusanatham et al., 1997). Such management drives the phase of
24 knowledge transformation by developing routines that aid in two ways. First, these
25 routines allow better absorption of the new knowledge proceeding from sources.
26 Second, they facilitate combination of the knowledge from these processes and from
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2 other sources—such as clients, providers or the competition—with the new knowledge
3 already acquired and assimilated. Throughout Six Sigma’s entire structure of process
4 management, discussed above (Choo et al., 2007; Linderman et al., 2003), the
5 methodology provides for the storing of information on the processes studied.
6 Following the methodology thus generates prior knowledge that acts as a facilitator of
7 absorptive capacity (Cohen and Levinthal, 1990; Gupta and Govindarajan, 2000; Van
8 den Bosch et al., 1999; Zahra and George, 2002). According to the foregoing, we
9 establish the following hypothesis:

10
11
12
13
14
15
16
17
18
19
20 H2: Process Management implemented in the Six Sigma methodology positively affects
21 absorptive capacity.
22
23
24
25

26 *2.4. Absorptive capacity and organizational learning orientation in Six Sigma*

27
28 Organizational learning orientation is defined as the “organization-wide activity of
29 creating and using knowledge to enhance competitive advantage” (Calantone et al.,
30 2002; p.516). Absorptive capacity plays an important role in learning (Cohen and
31 Levinthal, 1990; Lane et al., 2001; 2006; Lyles and Salk, 1996; Tu et al., 2006). Cohen
32 and Levinthal (1990) affirm that the ability to learn in the organization depends on the
33 absorptive capacity of the organization’s members. Absorptive capacity represents a
34 unit’s capacity to learn (Tsai, 2001). It is an integral part of learning process (Fosfuri
35 and Tribó, 2008). Learning will depend on an organization’s ability to recognize
36 valuable new knowledge, assimilate it, and use it for commercial ends (Cohen and
37 Levinthal, 1990). In greater detail, Lichtenthaler (2009) explains that exploratory
38 learning involves knowledge acquisition (Lane et al., 2006) and corresponds to the
39 notion of potential absorptive capacity (Zahra and George, 2002), whereas exploitative
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2 learning relates to knowledge assimilation and exploitation (Lane et al., 2006;
3
4 Lichtenthaler, 2009; Todorova and Durisin, 2007), reflecting the concept of realized
5
6 absorptive capacity (Zahra and George, 2002). According to Kim (1998), organizational
7
8 learning is a function of an organization's absorptive capacity. In this study, the author
9
10 observed how Hyundai Motor Company developed a strategy in developing absorptive
11
12 capacity of trying to improve the learning orientation. Schilling (2002, p.390) affirmed
13
14 that "if firms want to be learning oriented, investing in learning creates absorptive
15
16 capacity and thereby improves the rate at which the firm can learn". Further, in terms of
17
18 prior knowledge and familiarity with new knowledge, Lane et al. (2006) affirm that
19
20 absorptive capacity results in assimilation of sought-after knowledge. Thus, we
21
22 establish the next hypothesis:
23
24
25

26 H3: Organizational learning orientation is positively related with absorptive capacity.
27
28
29

30 3. Research method

31 3.1. Data sample

32
33 The sample used to contrast the hypotheses proposed is formed of manufacturing firms
34
35 and services in the European Union. The firms contacted were chosen randomly from
36
37 the Amadeus database and the publication *Actualidad Económica* (2004). The
38
39 procedure for data collection consisted of sending a letter by email explaining the
40
41 research project to different European firms. The card was addressed to the person
42
43 responsible for quality management in the firm and explained the reasons for and
44
45 objectives of the research. It included a direct link to a questionnaire available on
46
47 Internet. From this link the questionnaire could be accessed, filled out online and, once
48
49 finished, sent automatically, keeping the responding person anonymity,
50
51
52
53
54
55
56
57
58
59
60

Deleted: .

1
2
3
4 The questionnaire was developed after an extensive review of the literature related to
5 quality management practices, absorptive capacity and learning orientation. Once
6 designed, the questionnaire was pre-tested by three quality managers, which enabled the
7 clarification of possible ambiguities, correction of errors and solution of formatting
8 problems. This paper is part of a larger study that analyzes the current functioning of
9 QM initiatives in Europe, but as the goal of this research was to study the Six Sigma
10 initiative, we considered only responses from firms that had implemented this
11 methodology. The larger global study had a target sample of 2500 organizations, from
12 which 254 responses were obtained, representing a response rate of 10.16%. Of these,
13 17 responses were eliminated because they were incomplete or contained an error. Thus,
14 the final sample was composed of 237 valid responses. Of these, only the respondents
15 who indicated that they used the Six Sigma methodology to a reasonable degree (as
16 discussed later) were used in this study. These numbered 58.
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31

32 Of the total of 58 Six Sigma firms, 31.03% belong to the machinery and components
33 sectors, 25.86% to different activities in the service sector, 20.68% to electricity and
34 electronics, and the remaining 22.41% to miscellaneous sectors. As to the number of
35 employees in each of the firms surveyed, 37.93% of the firms had from 51 to 250
36 employees, 36.20% from 251 to 1000, and 25.86% over 1000 workers. A breakdown of
37 the countries of origin in the sample shows that most of the organizations analyzed are
38 from Spain (55.17%). Italy also represents a significant part of the sample (18.96%).
39 Finally, Austria and the United Kingdom represent 13.79% and 12.06%, respectively.
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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 multicollinearity between the variables analysed we calculate the factors of inflation variance (FIV) and the condition

1
2 index. The results obtained take values below the maximum recommended (Kleinbaum,
3
4 1988), eliminating the possibility of multicollinearity. Recommended values of fit
5
6 indices (RMSEA, GFI, CFI, etc.) for satisfactory fit of a model to data are presented in
7
8 Table II.
9

10
11
12 Insert Table II about here
13

14
15
16 Figure 1 depicts the SEM results of the relationships between teamwork and process
17
18 management, absorptive capacity and learning orientation, in Six Sigma firms. Each
19
20 path in the figure indicates the associated hypothesis as well as the estimated path
21
22 coefficients and *t*-values (*t*-values for path coefficients greater than 1.65 are significant
23
24 at $p < 0.10$; *t*-values for path coefficients greater than 1.96 are significant at $p < 0.05$; *t*-
25
26 values for path coefficients greater than 2.58 are significant at $p < 0.01$).
27
28

29
30 Insert Figure I about here
31

32
33 We can see that teamwork has a positive and significant effect ($p < 0.01$) on absorptive
34
35 capacity, leading us to accept Hypothesis 1. Hypothesis 2, which affirms that processes
36
37 management in Six Sigma affects the organization's absorptive capacity positively and
38
39 significantly, is also accepted. We can see how it has a positive and significant influence
40
41 ($t = 1.99$, $p < 0.05$). Finally, Hypothesis 3, which establishes that absorptive capacity
42
43 affects the organization's learning orientation, is also confirmed. The results of the
44
45 model show a positive and significant influence ($t = 1.43$, $p < 0.01$).
46
47
48

49 4. Discussion of results
50
51
52
53
54
55
56
57
58
59
60

1
2 The main goal of this study is to observe whether the teamwork and process
3 management proposed by the Six Sigma methodology influence positively the
4 development of absorptive capacity in the organization. We analyse in greater empirical
5 depth the possible reasons for Six Sigma initiative success. Further, this paper
6 contributes to the emerging literature that analyses the effects of absorptive capacity on
7 organizational learning orientation.
8
9
10
11
12
13

14
15
16 First, when we observe the effect of Six Sigma teamwork on absorptive capacity, we
17 see that our results contribute to the literature supporting the positive relation between
18 the mechanisms for integrating workers and absorptive capacity (Cohen and Levinthal,
19 1990; Jansen et al., 2005; Lane et al., 2006; Todorova and Durisin, 2007; Van den
20 Bosch et al., 1999; Zahra and George, 2002). Until now, we have not had empirical
21 evidence of this fact in organizations that implement the Six Sigma methodology. This
22 result thus constitutes an important research contribution. As mentioned above, one of
23 the most important characteristics of Six Sigma is teamwork. It is a methodology that
24 grounds much of its functioning in teamwork (Breyfogle, 2003; Pande et al., 2002). The
25 work teams are cross-functional, interdepartmental teams with coordination
26 mechanisms that facilitate the exchange of knowledge between units. These teams are
27 constructed in an open and supportive climate (Dahlgaard and Dahlgaard-Park, 2006;
28 Lloréns et al., 2006), which facilitates creativity and communication between workers.
29 Tu et al. (2006) have indicated that organizational climate, and in this case an open and
30 supportive climate, has positive repercussions for absorptive capacity. This study
31 continues the line of research begun by Park et al. (2009), who confirmed that Six
32 Sigma teams permit the creation and capturing of information, the storing and sharing
33 of information, and the use of information in the DMAIC cycle. Our study allows us to
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2 affirm that Six Sigma teams enable the development of their absorptive capacity,
3 contributing to learning, as we will see later. Our study also contributes to Jansen et al.
4 (2005) work, although it does not manage to determine whether this positive effect is
5 due to the lateral communication mechanisms that influence the first two phases
6 (acquisition and assimilation), or whether the effect is due to the combination of
7 knowledge that affects the last two phases (transformation and exploitation). Future
8 lines of study can achieve the depth achieved in the study by Jansen et al. (2005).
9

10
11 Secondly, Lloréns et al. (2006) have established theoretically that Six Sigma teamwork
12 differs from teamwork included in other quality initiatives, mainly due to the creation of
13 specialized positions to run its projects rather than overloading the firm's managers.
14 Further, the Black Belts and Green Belts are responsible for leading teams and
15 improvement projects (Gitlow, 2005; Pande et al., 2002). To do this, they foster the
16 participation of the workers, formalize the work that they perform and encourage the
17 workers to work as a team. People in these positions direct learning efforts (Choo et al.,
18 2007; Wiklund and Wiklund, 2002), becoming a resource available to help in the
19 development of absorptive capacity (Choo et al., 2007). Further, according to Lenox
20 and King (2004, p.331), "managers can develop absorptive capacity by directly
21 providing information to agents in the organization". This work of information
22 provision can be performed by the positions created in Six Sigma work teams, primarily
23 by the "Champions" and the "Master Black Belts", the positions of greatest
24 responsibility, constituting a very important contribution to the development of
25 absorptive capacity.
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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

1
2 firm to learn from another is determined by the relative characteristics of each firm.
3
4 Thus, absorptive capacity will be greater when culture is shared (norms, values, etc.) or
5
6 when the firms have similar operating priorities (similar business, etc.). If we translate
7
8 this concept to an internal perspective, as Tu et al. (2006) do with the definition of
9
10 absorptive capacity, Six Sigma typically brings about a cultural change in the
11
12 organization. Lee et al. (2009) identify this change as the most important aspect of the
13
14 methodology. Thus, the right cultural change, with a clear communication plan and
15
16 channels that motivate the employees to overcome resistance to change (Antony and
17
18 Bañuelas, 2001) will produce work units that share all of the characteristics indicated by
19
20 Lane and Lubatkin (1998) and Lane et al. (2001), developing the presence of relative
21
22 absorptive capacity.
23
24
25

26 Fourthly, although process management in Six Sigma methodology, may not contribute
27
28 any new content (Gijo et al., 2005) it does differentiate this initiative from others by
29
30 granting quality management greater structure and formality (Breyfogle, 2003; Pande et
31
32 al., 2002). The greater formality and structuring of the statistical techniques used offer
33
34 another possible explanation for the success of Six Sigma. The great importance
35
36 attributed to statistical process control in Six Sigma makes it the strongest technique for
37
38 quality improvement from the statistical perspective (Lloréns et al., 2006). This
39
40 differentiates it from other initiatives that are weaker from the perspective of, for
41
42 example, the ISO standards. This formality and structuring of Six Sigma process
43
44 management points toward the line of study developed by Choo et al. (2007). Our study
45
46 enriches this research line, since the authors, with Zu et al. (2008), argue that these are
47
48 the reasons that Six Sigma facilitates knowledge acquisition. Our study has shown
49
50 empirically the positive effect on an intermediate variable, absorptive capacity.
51
52
53
54
55
56
57
58
59
60

1
2
3
4 This study thus adds to the small number of empirical studies that observe the positive
5 effects of Six Sigma on organizations (Antony et al., 2005; 2007; Lee et al., 2006;
6 Gutiérrez et al., 2009). Our results allow us to explain Six Sigma's success from a
7 perspective of teamwork and process management used. We do not see the direct
8 relation of the Six Sigma practices to variables of performance such as improvement in
9 competitiveness (Lee et al., 2006), profitability or market share (Antony et al., 2005;
10 2007). However, the results show a positive effect on an intermediate variable,
11 *absorptive capacity*, which, as we will discuss next, affects another variable
12 fundamental to obtaining competitive advantage, organizational learning. This study
13 thus provides a possible reason for Six Sigma's positive results, one that follows the
14 lines of Choo et al. (2004; 2007), who observe that formality and structuring in Six
15 Sigma firm affect knowledge creation positively. We must not forget, however, that part
16 of the literature supports a relationship in the opposite direction, where knowledge
17 management constitutes an aid to quality management (Darroch 2003; 2005; Darroch et
18 al., 2003; Gowen et al., 2008; Yeung et al., 2007).

19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36 Finally, the results show a positive and significant effect of absorptive capacity on
37 organizational learning orientation. Because this relationship is already justified in the
38 literature (Cohen and Levinthal, 1990; Lane et al., 2001; 2006; Lyles et al., 1996; Tu et
39 al., 2006), the contribution of our study lies in observing this relationship in the context
40 of the Six Sigma initiative, thus establishing a connection of practices like teamwork
41 and process management to organizational learning by means of absorptive capacity, an
42 issue absent in the research literature and whose exploration has been requested by
43 previous studies (Choo et al., 2007; Gowen et al., 2008; Wiklund and Wiklund, 2002).
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

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,

1
2 Malcolm Baldrige, EFQM model, Six Sigma, Lean Manufacturing, etc). The results
3
4 obtained permit us to provide a more detailed description of one of these initiatives,
5
6 observing two practices that can help to differentiate it (teamwork and process
7
8 management) and which have positive effects for the organization. This knowledge can
9
10 be very useful for managers who find themselves faced with the decision of choosing
11
12 between various options for managing quality, especially those whose organizations
13
14 operate in environments where absorptive capacity and learning organizations are very
15
16 important. The findings of this study offer a justification of Six Sigma implementation
17
18 in firms. Further, the results drive the development of absorptive capacity within
19
20 organizations, due to their positive relation, in this case, to orientation to learning.
21
22 Besides, we must remark that the role of management is crucial in this development.
23
24

25
26 Some of the main lines for future research have been mentioned in the previous section.
27
28 These include studying in greater depth the effects of Six Sigma practices on the
29
30 different phases of knowledge absorption (potential and realized absorptive capacity). It
31
32 could also be valuable to examine the Six Sigma methodology from a perspective of
33
34 cultural change in the organization, considering how cultural change can affect relative
35
36 absorptive capacity. In any case, the literature on the methodology and its effects on
37
38 performance, is still scarce, such that all of the knowledge obtained on the functioning
39
40 and results will be very helpful. Thus, other structural aspects of this methodology, such
41
42 as supplier management (Bañuelas et al., 2003; Breyfogle, 2003) and design of
43
44 products, processes and services (DFSS¹) (Breyfogle, 2003; Pande et al., 2002), could
45
46 also serve as an orientation for continuing in-depth analysis of the real reasons for the
47
48 success of Six Sigma.
49

50
51
52 ¹ DFSS="Design for Six Sigma".
53
54
55
56
57
58
59
60

1
2
3
4 Finally, among the limitations of our study, we must include the fact that Six Sigma
5 implementation is examined using a single item testing its development degree, instead
6 of a compound construct. The sample of Six Sigma firms is not distributed uniformly
7 between the observed countries. Together with the cross-sectional character of the
8 research, this factor somewhat limits generalization from our results. Further,
9 longitudinal research that analyses a greater number of cases and that observes effects
10 on real results of organizations could enrich the literature on the Six Sigma quality
11 management initiative and the success it brings.
12
13
14
15
16
17
18
19
20
21

22 **References**

23
24 Abrams, L.C., Cross, R.C., Lesser, E. and Levin, D.Z., 2003. Nurturing interpersonal
25 trust in knowledge-sharing networks, *Academy of Management Executive*, 17 (4), 64-
26 79.
27
28

29
30 Actualidad Económica, 2004. *Cuáles son, cuánto venden y quién manda en las 5.000*
31 *mayores empresas*, Octubre 2004, No 2419.
32

33
34 Anderson, J.C., Rungtusanatham, M., Schroeder, R.G. and Devaraj, S., 1995. A Path
35 Analytic Model of a Theory of Quality Management Underlying the Deming
36 Management Method: Preliminary Empirical Findings. *Decision Sciences*, 26 (5), 637-
37 658.
38

39
40 Antony, F., Kumar, M. and Choo, B., 2007. Six sigma in service organisations:
41 Benefits, challenges and difficulties, common myths, empirical observations and
42 success factors. *International Journal of Quality & Reliability Management*, 24 (3),
43 294-311.
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60

1
2 Antony, F., Kumar, M. and Madu, C., 2005. Six sigma in small- and medium-sized UK
3 manufacturing enterprises: Some empirical observations. *International Journal of*
4 *Quality & Reliability Management*, 22 (8), 860-874.

5
6
7
8 Antony, J. and Bañuelas, R., 2001. Six Sigma: A business strategy for manufacturing
9 organizations. *Manufacturing Engineering*, 80 (3), 119-121.

10
11
12 Autio, E., Sapienza, H.J. and Almeida, J.G., 2000. Effects of age at entry, knowledge
13 intensity, and imitability on international growth. *Academy of Management Journal*, 43
14 (5), 909-924.

15
16
17
18 Baker, W.E. and Sinkula, J.M., 1999. The Synergistic Effect of Market Orientation and
19 Learning Orientation on Organizational Performance. *Journal of the Academy of*
20 *Marketing Science*, 27 (4), 411-429.

21
22
23
24 Bañuelas, R. and Antony, F., 2003. Going from six sigma to design for six sigma: an
25 exploratory study using analytic hierarchy process. *The TQM Magazine*, 15 (5), 334-
26 344.

27
28
29
30 Barkema, H.G. and Vermeulen, F., 1998. International expansion through start-up or
31 acquisition: A learning perspective. *Academy of Management Journal*, 41 (1), 7-26.

32
33
34 Breyfogle, F.W., 2003. *Implementing Six Sigma: Smarter Solutions Using Statistical*
35 *Methods*, New Jersey: Ed. Wiley.

36
37
38 Byrne, B.M., 1998. *Structural Equation Modelling with Lisrel, Preliis and Simplis:*
39 *Basic concepts, Application, and Programming*. Lawrence Erlbaum, Mahwah, NJ.

40
41
42 Calantone, R.J., Cavusgil, S.T. and Yushman, Z., 2002. Learning orientation, firm
43 innovation capability and firm performance. *Industrial Marketing Management* 31 (6),
44 515-524.

45
46
47
48 Cheng, J., 2009. Six Sigma and TQM in Taiwan: An empirical study of discriminate
49 analysis. *Total Quality Management & Business Excellence*, 20 (3), 311-326.

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
- 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.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.
- Dahlgard, J.J. and Dahlgard-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.

1
2 Fosfuri, A. and Tribó, J.A., 2008. Exploring the antecedents of potential absorptive
3 capacity and its impact on innovation performance. *Omega*, 36 (2), 173-187.

4
5
6 Gijo, E.V. and Rao, T.S., 2005. Six Sigma implementation – Hurdles and more hurdles.
7
8 *Total Quality Management & Business Excellence*, 16 (6), 721-725.

9
10 Gitlow, H., 2005. *Six Sigma for green belts and champions: foundations, DMAIC, tools,*
11
12 *cases, and certification.* US Prentice Hall Ed.2005.

13
14 Goh, T.N., Low, P.C., Tsui, K.L. and Xie, M., 2003. Impact of Six Sigma
15 implementation on stock price performance. *Total Quality Management & Business*
16
17 *Excellence*, 14 (7), 753-763.

18
19
20 Gowen, C.R., Stock, G.N. and Mcfadden, K.L., 2008. Simultaneous implementation of
21
22 Six Sigma and knowledge management in hospitals. *International Journal of*
23
24 *Production Research*, 46 (23), 6781- 6795.

25
26 Green, F., 2006. Six Sigma and the revival of TQM. *Total Quality Management &*
27
28 *Business Excellence*, 17 (10), 1281-1286.

29
30 Gupta, A. and Govindarajan, V., 2000. Knowledge flows within multinational
31
32 corporations. *Strategic Management Journal*, 21 (4), 473-496.

33
34 Gutiérrez, L., Lloréns-Montes, F.J. and Bustinza, O., 2009. Six Sigma: From a goal-
35
36 theoretical perspective to shared-vision development. *International Journal of*
37
38 *Operations and Production Management*, 29 (2), 151-169.

39
40 Hair, J.F., Anderson, R.E., Tatham, R.L. and Black, W.C., 2004. *Análisis multivariante.*
41
42 5th Ed. Madrid: Prentice Hall.

43
44 Hann, G.J., Hill, W.L., Hoerl, R.W. and Zinkgraf, S.A., 1999. The impact of Six Sigma
45 improvement-a glimpse in the future of statistics. *The American Statistician*, 53 (3),
46
47 208-215.

48
49 Harry, M.J., 2000. *Six Sigma*, New York: Currency.
50
51
52
53
54
55
56
57
58
59
60

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
- 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.
- Hulland, J., 1999. Use of partial least squares (PLS) in strategic management research: A review of four recent studies. *Strategic Management Journal*, 20 (2), 195-204.
- 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.
- 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.

1
2 Lane, P.J., Koka, B. and Pathak, S., 2006. The reification of absorptive capacity: a
3 critical review and rejuvenation of the construct. *Academy of Management Review*, 31
4 (4), 833-863.
5
6

7
8 Lane, P.J., Salk, J. and Lyles, M., 2001. Absorptive Capacity, Learning, and
9 Performance in International Joint Ventures. *Strategic Management Journal*, 22 (12),
10 1139-1161.
11
12

13
14 Lapré, M.A., Mukherjee, A.S. and Van Wassenhove, L.N., 2000. Behind the learning
15 curve: linking learning activities to waste reduction. *Management Science*, 46 (5), 597-
16 611.
17
18

19
20 Lee, K. and Choi, B., 2006. Six sigma management activities and their influence on
21 corporate competitiveness. *Total Quality Management & Business Excellence*, 17 (7),
22 893-911.
23
24

25
26 Lee, K., Wei, C. and Lee, H., 2009. Reducing exposed copper on annular rings in a PCB
27 factory through implementation of a Six Sigma project. *Total Quality Management &*
28 *Business Excellence*, 20 (8), 863 – 876.
29
30

31
32 Lenox, M. and King, A., 2004. Prospects for developing absorptive capacity through
33 internal information provision. *Strategic Management Journal*, 25 (4), 331-345.
34
35

36
37 Liao, J., Welsch, H. and Stoica, M., 2003. Organizational Absorptive Capacity and
38 Responsiveness: An Empirical Investigation of growth oriented SMEs.
39 *Entrepreneurship Theory and Practice*, 28 (1), 63-85.
40
41

42
43 Lichtenthaler, U., 2009. Absorptive capacity, environmental turbulence, and the
44 complementarity of organizational learning processes. *Academy of Management*
45 *Journal*, 52 (4), 822-846.
46
47

48
49 Linderman, K. and Schroeder, R.G., Choo, A.S., 2006. Six Sigma: the role of goal in
50 improvement teams. *Journal of Operations Management*, 24 (6), 779-790.
51
52
53
54
55
56
57
58
59
60

- 1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
- 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.
- Nunally, J., 1978. *Psychometric Theory*. McGraw Hill. New York.

1
2 Oakland, J.S., 1989. *Total Quality Management: The Route for Improving Performance*.
3
4 Oxford: Butterworth-Heinemann.

5
6 Pande, P.S., Neuman, R.P. and Cavanagh, R.R., 2002. *Las claves de Seis Sigma: La*
7
8 *implantación con éxito de una cultura que revoluciona el mundo empresarial*. Madrid:
9
10 Ed. McGraw Hill.

11
12 Park, S.H., Ntuen, C.A. and Park, E.H., 2009. A new paradigm of Six Sigma:
13
14 Knowledge-based Digital Six Sigma. *Total Quality Management & Business*
15
16 *Excellence*, 20 (9), 945-952.

17
18 Pearce, C.L. and Ensley, M.D., 2004. A reciprocal and longitudinal investigation of the
19
20 innovation process: the central role of shared vision in product and process innovation
21
22 teams (PPITs). *Journal of Organizational Behaviour*, 25 (2), 259-278.

23
24 Ravichandran, J., 2006. Six-Sigma Milestone: An Overall Sigma Level of an
25
26 Organization. *Total Quality Management & Business Excellence*, 17 (8), 973-980.

27
28 Rindova, V.P. and Fombrun, C.J., 1999. Constructing competitive advantage: the role of
29
30 firm-constituent interactions. *Strategic Management Journal*, 20 (8), 691-710.

31
32 Rogers, E. M., 1995. *Diffusion of Innovations*. Free Press, New York

33
34 Rungtusanatham, M., Anderson, J.C. and Dooley, K.L., 1997. Conceptualizing
35
36 Organizational Implementation and Practice of Statistical Process Control. *Journal of*
37
38 *Quality Management*, 2 (1), 113-137.

39
40 Saraph, J.V., Benson, P.G. and Schroeder, R.G., 1989. An Instrument for Measuring the
41
42 Critical Factors of Quality Management. *Decision Sciences*, 20 (4), 810-830.

43
44 Schilling, M.A., 2002. Technology success and failure in winner-take-all markets: the
45
46 impact of learning orientation, timing, and network externalities. *Academy of*
47
48 *Management Journal*, 45 (2), 387-398.

- 1
2 Schroeder, R.G., Linderman, K., Liedtke, C. and Choo, A.S., 2008. Six Sigma:
3 Definition and underlying theory. *Journal of Operations Management*, 26 (4), 536-554.
4
5
6 Senge, P., 1999. It's the learning: the real lesson of the quality movement. *Journal for*
7
8 *Quality and Participation*, 22 (6), 34-40.
9
10 Shamji, N., 2005. Six Sigma Basics. *Total Quality Management*, 16 (5), 567-574.
11
12 Silos, I.M., 1999. Employee involvement-a component of Total Quality Management.
13
14 *Production and Inventory Management Journal*, 40 (1), 56-65.
15
16 Sinha, K.K. and Van de Ven, A.H., 2005. Designing work within and between
17
18 organizations. *Organization Science*, 16 (4), 389-408.
19
20 Sinkula, J.M., Baker, W.E. and Noordewier, T.A., 1997. Framework for market-based
21
22 organizational learning: linking values, knowledge, and behaviour. *Journal of Academic*
23
24 *Marketing Science*, 25 (4), 305-318.
25
26 Sousa, R. and Voss, C.A., 2002. Quality management re-visited: A reflective review
27
28 and agenda for future research. *Journal of Operations Management*, 20 (1), 91-109.
29
30 Szulanski, G., 1996. Exploring internal stickiness: Impediments to the transfer of best
31
32 practice within the firm. *Strategic Management Journal*, 17 Winter Special Issue, 27-
33
34 43.
35
36 Thawani, S., 2004. Six Sigma-strategy for organizational excellence. *Total Quality*
37
38 *Management*, 15 (5/6), 655-664.
39
40 Tien Shang, L. and Hsin Ju, T., 2005. The effects of business operation mode on market
41
42 orientation, learning orientation and innovativeness. *Industrial Management & Data*
43
44 *Systems*, 105 (3), 325-348.
45
46 Todorova, G. and Durisin, B., 2007. Absorptive capacity: valuing a reconceptualization.
47
48 *Academy of Management Review*, 32 (3), 774-786.
49
50
51
52
53
54
55
56
57
58
59
60

1
2 Tsai, W., 2001. Knowledge transfers in Intra-Organizational Networks. *Academy of*
3 *Management Journal*, 44 (5), 996-1004.

4
5
6 Tu, Q., Vonderembse, M.A., Ragu-Nathan, T.S. and Sharkey, T.W., 2006. Absorptive
7 capacity: Enhancing the assimilation of time-based manufacturing practices. *Journal of*
8 *Operations Management*, 24, 692-710.

9
10
11 Van Den Bosch, F., Volberda, H. and De Boer, M., 1999. Coevolution of firm
12 absorptive capacity and knowledge environment: organizational forms and combinative
13 capabilities. *Organization Science*, 10 (5), 551-568.

14
15
16 Van Iwaarden, I., Van Der Wiele, T., Dale, B., Williams, R. and Bertsch B., 2008. The
17 Six Sigma improvement approach: a transnational comparison. *International Journal of*
18 *Production Research*, 46 (23), 6739-6758.

19
20
21 Wiklund, H. and Wiklund, P.S., 2002. Widening the Six Sigma concept: an approach to
22 improve organizational learning. *Total Quality Management*, 13 (2), 233-239.

23
24
25 Yeung, A.C.L., Lai, K.H. and Yee, R.W.Y., 2007. Organizational learning,
26 innovativeness, and organizational performance: a qualitative investigation.
27 *International Journal of Production Research*, 45 (11), 2459-2477.

28
29
30 Zahra, S. and George, G., 2002. Absorptive Capacity: A review, reconceptualization,
31 and extension. *Academy of Management Review*, 22 (2), 185-203.

32
33
34 Zahra, S., Ireland, R.D. and Hutt. M.A., 2000. International expansion by new venture
35 firms: international diversity, mode of market entry, technological learning, and
36 performance. *Academy of Management Journal*, 43 (5), 925-950.

37
38
39 Zu, X., Fredendall, L.D. and Douglas, T.J., 2008. The evolving theory of quality
40 management: The role of Six Sigma. *Journal of Operations Management*, 26 (5), 630-
41 650.

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
1. The new knowledge acquired is in agreement with existing knowledge in the organisation (Item deleted after unidimensionality 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					0.924

	et al. (1997)				
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

^aHulland (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 degrees	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

^aHair et al. (2004) y Byrne (1998).

^bByrne (1998).

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

