

# Leadership – a critical success factor for the effective implementation of Lean Six Sigma

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**Abstract**

The objective of this paper is to offer further insights into Lean Six Sigma deployment, highlighting the more important critical success factors (CSFs) and particularly the role of leadership in successful deployment. Identification of CSFs for Lean Six Sigma is important as it allows organisations to focus their efforts on these factors to ensure success. The study is in two parts: the first part reviews the literature on leadership, Lean Six Sigma and CSFs for continuous improvement programmes. The second part illustrates the results of a longitudinal study through the administration of a survey questionnaire and exploratory factor analysis of the answers.

The results suggest that the most important and significant factors for the effective implementation of Lean Six Sigma are: project management, leadership, selection of top talented people and financial accountability. Although they highlight the importance of leadership as a critical success factor for effective deployment of Lean Six Sigma, more research is needed to determine what type of leadership is appropriate at different stages of Lean Six Sigma programme maturity.

**Keywords:** Lean, Six Sigma, Leadership, Critical Success Factors

## 1. Introduction

As the quality of products and services is critical to a firm's success, many attempts have been made over the years to deploy continuous improvement programmes to improve quality, and Lean

Six Sigma is one of the most frequently used frameworks for continuous improvement: it is a business improvement methodology that aims to maximise shareholder value by improving quality, speed, customer satisfaction, and costs. While Lean Six Sigma has been successfully deployed in companies success reported by companies such as Motorola, General Electric, Caterpillar and other global brands has helped to increase its adoption across industries (Desai, 2006), there are many examples of unsuccessful deployment (Chakravorty, 2009) and its However, Lean Six Sigma implementation is fraught with problems (Gijo & Rao, 2005), and there are many examples of its unsuccessful deployment in organisations: there is increasing concern about implementation failures (Chakravorty, 2009), and v Various critical success factors (those factors essential to the success of any program and technique, have been identified and discussed in the literature (Rungasamy, Antony, & Ghosh, 2002), with the focus mostly on have been identified and discussed in the literature.

What makes some continuous improvement programmes successfully transform an organisation and others easily forgotten? For anyone involved in operational excellence, there is probably no more important question. In trying to answer it, most prior studies on critical success factors have focused on techniques or tools to aid the implementation: this study, instead, investigates the influence of leadership on individual quality management practices. This research contributes to the existing literature in two ways: first, it operationalises the many success factors in four critical ones; second, it establishes leadership as one of these four critical success factors.

This contribution not only adds to our understanding of Lean Six Sigma practices but should be of particular interest to industry's community of practice, enlightening Lean Six Sigma practitioners who are in the midst of deployment, or indeed any organisations considering the Lean Six Sigma

~~path and wondering what is needed to make it a success: it takes leadership to start a continuous improvement programme and keep it on track despite the many distractions and the resistance met in an organisation. Does the leadership have what it takes?~~

The paper is structured as follows: the relevant Lean Six Sigma and leadership literature is reviewed in Section 2, and the critical success factors for Lean Six Sigma are illustrated in Section 3. Empirical results are presented in Section 4, ~~and~~ Section 5 presents a discussion of the findings, research and managerial implications, ~~with the conclusion in Section 6~~ ~~limitations and future research opportunities.~~

## 2. Literature review

### 2.1 Lean Six Sigma

Lean Six Sigma is a business improvement methodology that aims to maximise shareholder value by improving quality, speed, customer satisfaction, and costs: it achieves this by merging tools and principles from both Lean and Six Sigma. It has been widely adopted in manufacturing and service industries, and its success in some well-known organisations (e.g. GE and Motorola) has created a copycat phenomenon with many organisations around the world anxious to replicate its success.

Lean and Six Sigma have followed independent paths since the 1980s, when the terms were first hard coded and defined: the first applications of Lean were recorded in the Michigan plants of Ford in 1913, and were then further developed in Japan (within the Toyota Production System), whereas Six Sigma saw the light in the United States (at the Motorola Research Center). *Lean* is a process improvement methodology used to deliver products and services better, faster, and at lower cost. Womack and Jones (1996) defined it as

a way to specify value, line up value-creating actions in the best sequence, conduct those activities without interruption whenever someone requests them, and perform them more

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7 and more effectively. In short, lean thinking is lean because it provides a way to do more  
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9 and more with less and less—less human effort, less human equipment, less time, and less  
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11 space—while coming closer and closer to providing customers with exactly what they want.

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13 *Six Sigma* is a data-driven process improvement methodology used to achieve stable and  
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15 predictable process results by reducing process variations and defects. Snee (1999) defined it as ‘a  
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17 business strategy that seeks to identify and eliminate causes of errors or defects or failures in  
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19 business processes by focusing on outputs that are critical to customers’.

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21 Despite their different origins, Lean and Six Sigma share some commonalities, such as an  
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23 emphasis on a culture of continuous improvement, customer satisfaction, comprehensive employee  
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25 involvement and search for root causes. Antony and Kumar (2012) list the following commonalities  
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27 and differences:

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30 **Table 1 Lean and Six Sigma commonalities and differences**

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34 Although both Lean and Six Sigma have been used for many years, they were not integrated  
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36 until the late 1990s and early 2000s (George, 2002, 2003), and today Lean Six Sigma is recognised  
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38 as ‘a business strategy and methodology that increases process performance resulting in enhanced  
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40 customer satisfaction and improved bottom line results’ (Snee, 2010). Lean Six Sigma uses tools  
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42 from both toolboxes in order to get the best from the two methodologies, increasing speed while  
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44 also increasing accuracy.

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46 The benefits of Lean Six Sigma in the industrial world (in both manufacturing and services sectors)  
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48 have been highlighted extensively in the literature (Zhang, Irfan, Khattak, Zhu, & Hassan, 2012)  
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50 and include the following (Antony, 2005a, 2005b).

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- 7 1. Ensuring services/products conform to what the customer needs ('voice of the
- 8 customer').
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- 11 2. Removing non-value adding steps (waste) in critical business processes.
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- 13 3. Reducing the cost of poor quality.
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- 15 4. Reducing the incidence of defective products/transactions.
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- 17 5. Shortening the cycle time.
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- 19 6. Delivering the correct product/service at the right time in the right place.
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22 One of the key elements differentiating Lean Six Sigma from previous quality initiatives is  
23 the organisation and structure of the quality implementation functions. In quality initiatives prior to  
24 Lean Six Sigma, the management of quality was relegated largely to the production floor and/or, in  
25 larger organisations, to statisticians in the quality department. Instead, Lean Six Sigma introduces a  
26 formal organisational infrastructure for different quality implementation roles, borrowing  
27 terminology from the world of martial arts to define hierarchy and career paths (Adams, Gupta, &  
28 Wilson, 2003; Antony, Kumar, & Madu, 2005; Antony, Kumar, & Tiwari, 2005; Harry &  
29 Schroeder, 2000; Pande, Neuman, & Cavanagh, 2000; Snee, 2004).

## 39 2.2 Leadership: synthesis of literature research

40 Leadership definitions abound in the literature: in 1991, 54 leadership experts from 38  
41 countries agreed on a common definition of leadership: 'Influencing, motivating, and enabling  
42 others to contribute toward the effectiveness and success of the organisations of which they are  
43 members' (House, Javidan, & Dorfman, 2001).

44 The following Tables [2a and 2b](#) summarises the leadership traits, [and main literature](#)  
45 [references](#), for the 10 most common leadership styles identified in the literature (Bass, 1990;  
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Hofstede, 1977; Kouzes & Posner, 1987; Schriesheim, 1982; Stogdill, 1989; Tannenbaum & Schmitt, 1958). ~~Here a brief description for each:~~

~~**5 Level:** the Level 5 leader sits on top of a hierarchy of capabilities and builds enduring company greatness through a paradoxical combination of personal humility plus professional will (Collins, 2001).~~

~~**Affiliative:** a leadership style where the leader promotes harmony among his or her followers and helps to resolve any conflict. This type of leader will also build teams that make sure that their followers feel connected to each other. Typically the followers will receive much praise from this style of leader, but poor performance tends to go unchecked (Goleman, Boyatzis, & McKee, 2004).~~

~~**Bureaucratic:** a style of leadership that emphasises procedures and historical methods regardless of their usefulness in changing environments. Bureaucratic leaders attempt to solve problems by adding layers of control, and their power comes from controlling the flow of information (Weber, 1905).~~

~~**Participative:** also known as Democratic style. The leader involves subordinates in goal setting, problem solving, team building etc., but retains the final decision making authority (Lewin, Lippitt, & White, 1939).~~

~~**Servant:** stresses the importance of the role a leader plays as the steward of the resources of a business or other organisation, and teaches leaders to serve others while still achieving the goals set out by the business (Greenleaf, 1977).~~

~~**Six Sigma:** advocates a higher standard of leadership effectiveness through the founding principles of Six Sigma, and is a model anyone can aspire to regardless of whether the company uses Six Sigma or not (Pande, 2007).~~

~~**Transactional:** based on the setting of clear objectives and goals for the followers as well as the use of either punishments or rewards to encourage compliance with these goals (Burns, 1978).~~

~~**Transcendent:** grounded in servant leadership, the transcendent style offers a pathway to increased trust necessary for global sustainability, offering a more inclusive and consensual decision-making process for the economic, social, and environmental sectors, moving beyond a singular focus on the bottom line of profits to a multiple focus on the triple bottom lines of profits, people, and planet (Gardiner, 2006).~~

~~**Transformational:** style of leadership in which the leader identifies the needed change, creates a vision to guide the change through inspiration, and executes the change with the commitment of the members of the group (Burns, 1978).~~

~~**Visionary:** leaders articulate where a group is going, but not how it will get there—setting people free to innovate, experiment, take calculated risks (Goleman et al., 2004).~~

Table 2a Leadership traits by leadership style

Table 2b Leadership styles' reference list

### 2.3 Overview of the relationship between leadership and Lean Six Sigma

Lean Six Sigma has been extremely successful in some organisations, where it is no longer only a cost reduction initiative but has also been embedded into the organisation's way of doing things: more well-known examples are probably Toyota for Lean (Liker, 2003) and GE for Six Sigma (Eckes, 2000). However, many other organisations struggle to turn Lean Six Sigma into a success because of different failure factors (Albliwi, Antony, Halim Lim, & van der Wiele, 2014), and the question is whether different styles and traits of leadership can have an impact on whether the deployment of Lean Six Sigma results in organisational success. As Deming said (1994), quality is



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7 determined by top management and cannot be delegated, and the quality of the output of a company  
8 cannot be better than the quality at the top (Hilton & Sohal, 2012; Suresh, Antony, Kumar, &  
9 Douglas, 2012). Existing theory suggests that in order to implement a quality improvement process  
10 successfully, an organisation needs to have transformational leaders at the top (Waldman, 1993) to  
11 create the culture and objectives which must be adopted by transactional leaders in the middle  
12 management ranks (Waldman et al., 1998).  
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19 Research shows an inextricable link between leadership and commitment (Aboelmaged, 2011;  
20 Martinez-Jurado & Moyano-Fuentes, 2012; Waldman et al., 1998) at the basis of the success of a  
21 quality improvement programme: unwavering commitment to quality programmes from top  
22 management is fundamental for embedding those into the organisation's culture, allowing it to  
23 overcome the initial scepticism of employees (Bhasin 2012a, 2012b; Juran, 1989).  
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29 Leadership has been recognised as a mechanism for embedding cultural values and norms into an  
30 organisation (Schein, 1983); at the same time, the idea of culture affecting the type of leadership in  
31 an organisation has been advanced (Bass, 1985), suggesting the existence of a reciprocal  
32 relationship between leadership and culture in organisations (Waldman, 1993). Overall, Lean Six  
33 Sigma deployment needs to proceed hand in hand with cultural change in order to avoid falling into  
34 the same traps into which TQM fell in previous generations of quality improvement programmes  
35 (Albliwi et al., 2014; Bushe, 1988).  
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43 Leadership and organisational culture look at conditions within the organisation, but Forker (1991)  
44 noted how societal-level differences exist in the way quality and continuous improvement are  
45 defined in the USA, Japan, and what was the USSR at the time his article was written: these  
46 societal-level differences have an impact on the organisational culture. Putting all this together,  
47 similarly to the TQM model introduced by Waldman (1993), we suggest the model displayed in  
48 Figure 1 for illustrating the links between leadership, culture, and Lean Six Sigma.  
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Figure 1 Model of leadership, culture and Lean Six Sigma, adapted from Waldman, 1993

This model illustrates the key relationships so far identified in the literature.

1. the reciprocal impact of leadership and culture within the organisation;
2. the societal-level factors outside the organisation that have an impact on the organisational culture;
3. how (A) and (B) above impact on the Lean Six Sigma behaviours of employees affected by both the leadership and the culture prevalent in the organisation;
4. all the above combine to generate the Lean Six Sigma outputs.

### 3. Lean Six Sigma: critical success factors (CSFs)

In this section, we discuss the CSFs for Lean Six Sigma and validate the following hypothesis:

*H1. Leadership is one of the main critical success factors for Lean Six Sigma deployment in organisations.*

Rockart (1979) illustrated the concept of CSFs and examined how they can be used to determine the informational needs of managers. According to Rungasamy et al. (2002), CSFs are those factors essential to the success of any programme or technique in the sense that if the objectives associated with the factors are not achieved the application of the technique may fail catastrophically. CSFs include issues vital to an organisation's current activities and future success (Boynlon & Zmud, 1984).

In the wealth of Lean Six Sigma literature, we identified 31 sources discussing CSFs for its implementation (22 articles and nine books) of which the resulting list of 19 CSFs is summarised in

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7 Table 2a. Antony and Banuelas (2002) analysed the key ingredients for the effective  
8 implementation of a Six Sigma programme in UK companies, and Coronado and Anthony (2002)  
9 further refined them to identify the top 10 CSFs encompassing a diverse range of skills from the  
10 more technical to leadership ones.  
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15 The importance of organisational infrastructure and culture was particularly highlighted by  
16 Zu, Robbins, and Fredendall (2010), whereas Pande et al. (2000) included leadership commitment  
17 as one of their CSFs. Johnson and Swisher (2003) focused on the training and selection aspect,  
18 identifying project selection and training of staff as CSFs, as did Halliday (2001).  
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24 Kwak and Anbari (2006) split CSFs into four main areas: management involvement and  
25 organisational commitment; project selection, management, and control skills; encouraging and  
26 accepting cultural change; and continuous education and training. Similarly, Achanga, Shehab,  
27 Roy, and Nelder (2006) identified four CSFs: leadership and management, finance, skills and  
28 expertise, and organisational culture. Kumar (2007) identified 13 CSFs for Six Sigma  
29 implementation in SMEs. The importance of organisational culture as a CSF was identified by  
30 Erwin (2000), and Dale (2000) highlighted the importance of linking Lean Six Sigma to the overall  
31 business strategy.  
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39 The need for a process management system, particularly for tracking and reviewing projects,  
40 was highlighted by Martens (2001), and Ingle and Roe (2001) went deeper into the subject,  
41 identifying the prioritisation of projects as a CSF. Antony (2006) added other CSFs to the literature,  
42 including selecting team members, understanding tools, linking Six Sigma to customers and  
43 accountability to the existing list of CSFs.  
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49 Henderson and Evans (2000) identified the following CSFs for Six Sigma: management  
50 support, organisational infrastructure, training, tools, and linking Six Sigma to human resources-  
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7 based actions (promotions, bonuses, etc.), whereas, in an appeal to statisticians, Hahn, Hill, Hoerl,  
8 and Zinkgraf (1999) identified leadership, training, and project involvement as CSFs.

11 Table 3a Summary of the CSFs from the literature

12 Table 3b Leadership literature references

#### 17 4. Research methodology and data collection

##### 19 4.1 Research Framework

20 Understanding the research framework and the more appropriate methodology for the study is a  
21 critical aim of researchers: the starting point of any research is to understand the nature of the  
22 research problem, leading to the choice of an appropriate research methodology (Rowlands, 2005).  
23 It is important to have a clear statement of purpose for the research (Yin, 2003): in this research we  
24 are taking an exploratory approach, focusing on what critical success factors apply to Lean Six  
25 Sigma, trying to identify the relationships shaping the phenomenon of Lean Six Sigma deployment  
26 in organizations. The study was conducted on an epistemological positivist stance, with the  
27 researcher assuming the role of an objective analyst, making detached interpretations through test  
28 on data collected in a value-free manner (Saunders, Lewis & Thornhill, 2003).

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##### 39 4.2 Research Methodology

40 In management research, different methodologes are commonly used, and choosing the most  
41 appropriate one depends on the research's questions and objectives (Saunders, Lewis & Thornhill,  
42 2003). The purpose of this study was to verify whether companies that implement Lean Six Sigma  
43 still recognise the same set of CSFs individuated in the literature and which they consider to be  
44 most important. To answer this question, a structured questionnaire, administered via email, was  
45 used. Survey research has been the most commonly used research method since the 1990s (Kumar,  
46 2010; Meredith, Raturi, Amoako-Gympah, & Kaplan, 1989) and has become the dominant form of

data collection in the social sciences, providing for efficient data collection over broad populations, administered in person, by telephone or over the internet (Easterby-Smith, Thorpe, & Lowe, 2002).

Bryman (1988, p.104) defined survey research as follows:

Survey research entails the collection of data on a number of units and usually at a single juncture in time, with a view to collecting systematically a body of quantifiable data in respect of a number of variables which are then examined to discern patterns of association.

It is a structured data collection technique whereby information about a person's perceptions, beliefs, feelings, motivations, anticipation, or future plans can be obtained (Antony, Antony, Kumar, & Cho, 2007), with the advantage that the respondents are asked exactly the same set of questions, thus enabling the statistical analysis of the results.

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#### **4.13** *Survey structure*

The survey used in this research was comprised of 18 questions, covering the background of respondents and organisations, criteria for the successful implementation of Lean Six Sigma in an organisation and CSFs for Lean Six Sigma implementation.

The first part of the questionnaire collected information on the seniority of the respondent, the size, location and sector of the organisation, and the extent of use of Lean Six Sigma in the organisation.

The second part of the questionnaire investigated the success metrics used in the organisation to determine whether the Lean Six Sigma efforts were successful, and asked the respondent to evaluate the programme's success so far. Finally, in the last section of the questionnaire, each respondent was asked to rank the 19 critical success factors outlined in the literature, or suggest new one(s) if they felt any was missing.

#### **4.12** *Type of questions*

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7 In the design of any survey, the response format is a major consideration, as it will affect the type  
8 and wording of the questions and the type of analysis that can be conducted subsequently (Fowler,  
9 2002). For this research a close-ended question format was used to allow for statistical analysis. In  
10 the last part of the questionnaire, the 19 CSFs from the literature were operationalised on a five-  
11 point Likert scale (1=Not Very Important; 2=Not Important; 3=Important; 4=Very Important;  
12 5=Critical), and respondents were asked to rank each factor from 1 to 19 (1=most important,  
13 2=second most important, etc.) in order to identify the importance of these 19 CSFs. The Likert  
14 scale provides a more precise measurement than yes/no type of questions (Neuman, 2003). The data  
15 collected were then analysed with Microsoft Excel and SPSS software.  
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#### 24 **4.53 Sampling method and procedure**

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27 The questionnaire was distributed electronically to 700 Lean Six Sigma professionals from various  
28 industries and countries: the list of companies was obtained from the database of the Department of  
29 Design, Manufacturing, and Engineering Management of Strathclyde University, plus a network of  
30 the professional contacts of the research team. The response rate was 20.5%, with 123 responses  
31 received: this was deemed satisfactory, as according to the maximum likelihood estimation (MLE),  
32 in order for the sample to be effectual the number of respondents should be between 100 and 10  
33 (Ding, Velicer, & Harlow, 1995). The questionnaire was targeted at those organisations,  
34 irrespective of industry sector, that had already implemented either Lean or Six Sigma or Lean Six  
35 Sigma.  
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#### 44 **4.46 Analysis of survey results**

##### 45 **4.64.1 Demographics**

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48 The analysis of the first part of the questionnaire provided a better understanding and context of the  
49 key findings of the study.  
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7 The majority of respondents were either master black belts (25%), black belts (24%), or function  
8 leads / managers (16%) in companies which mostly had more than 1,000 employees (70%) who  
9 responded to the survey. Of the 20 areas of industry selected for this survey, industrial goods &  
10 services, financial services, automotive, and computer & services accounted for 40% of total  
11 responses. Almost half (48%) of the companies had implemented Lean Six Sigma for cost savings  
12 or cost avoidance (e.g. less waste, inventory levels): this was by far the most cited reason for  
13 implementation, followed at some distance by productivity increases (18%) and customer  
14 satisfaction (13%). More than half of companies (58%) used Lean and Six Sigma together in  
15 tandem, 22% used Lean on its own, and only 11% used Six Sigma on its own. A third of  
16 respondents' companies applied Lean Six Sigma to all their business units, with half applying it to  
17 more than one business unit. The business units cited more frequently as implementing Lean Six  
18 Sigma were operation / production, supply chain, logistics, finance, and customer service. Two-  
19 thirds (66%) of respondents considered the implementation of Lean Six Sigma to be either  
20 successful or extremely successful; about 3% considered it to be either unsuccessful or extremely  
21 unsuccessful, with the remaining 31% observing no significant impact either way.  
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#### 41 *4.6.4.2 Reliability test*

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44 In order to measure the consistency of the survey, a reliability test was conducted. Reliability offers  
45 'an indication of consistency between two measure of the same thing' (Black, 1999). According to  
46 Cramer (1998), 'reliability is particularly important in connection with multiple item scales', and he  
47 indicated three main types of tests for assessing data reliability: Cohen's kappa coefficient, Ebel's  
48 intraclass correlation, and Cronbach's alpha coefficient. Cronbach's alpha coefficient is the most  
49 widely used (Black, 1999), and this was therefore calculated with JMP software: an alpha  
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7 coefficient of 0.6 or higher is considered to be an acceptable level of internal consistency. The  
8 results indicated an overall Cronbach's coefficient of 0.855; hence, we could infer that the data  
9 collected were suitable for analysis.  
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#### 11 12 13 **4.75 Analysis of CSFs** 14

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16 Respondents to the survey were asked to score on a Likert scale their perceived importance of each  
17 CSF, with 1=Not Very Important; 2=Not Important; 3=Important; 4=Very Important; 5=Critical. A  
18 factor with the highest mean score was considered to be the most important factor.  
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21 The t-tests indicated no significant differences among demographic variables (at the 95%  
22 significance level), including the number of employees in the organisation or whether the  
23 organisation implemented only Lean, only Six Sigma, or the two together, meaning respondents  
24 from different-sized organisations and those that implemented either Lean or Six Sigma first  
25 answered in a similar way.  
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29 As the survey was longitudinal in nature, spread over time, the difference between early and late  
30 respondents was tested (Armstrong & Overton, 1997). The final sample was split into two  
31 depending on the dates the questionnaires were received: the earlier group consisted of the replies  
32 received after the first two distributions of the survey, whereas the second group included the  
33 replies received after the fourth email: the  $\chi^2$  test yielded no statistically significant differences (at  
34 the 95% significance level).  
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#### 44 **4.83 Exploratory factor analysis (EFA)** 45

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47 An EFA (Norris & Lecavalier, 2010) was utilised to analyse the results of the survey. Factor  
48 analysis is a family of statistical methods whose goal is to identify the underlying relationships  
49 between variables: as per Finch and West (1997), EFA is the most appropriate technique when there  
50 is no a priori hypothesis about factors or patterns of measured variables; it is used to determine the  
51 number of latent variables (factors) that are needed to explain the correlations among a set of  
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7 observed variables. In this case, we applied it to the 19 CSFs to determine the existence of any  
8 underlying relationships.

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11 EFA has four assumptions: variables are normal, have a linear relation, have a minimum amount of  
12 correlation and have a sample size with a cases/items ratio of at least 5:1 (for the 19 CSFs in our  
13 study-, that implied at least 95 responses). These assumptions were tested in SPSS for the data set.  
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18 The first step in the EFA was to measure the associations between variables by using a correlation  
19 matrix. Two factors (Lean Six Sigma training and awareness) had cummunalities greater than one,  
20 and hence they were removed from the model: communality is the percentage of variance in a given  
21 variable explained by all the factors jointly; a communality  $>1$  is an indication of a spurious  
22 solution, reflecting too many factors, that can therefore be eliminated (Gorsuch, 1983).  
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28 The model resulting from the remaining 17 factors had the following correlation matrix (Table 3),  
29 where all communalities are  $<1$ :  
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34 **Table 4 Correlation matrix**

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38 We then used Kaiser's (1960) eigenvalue-greater-than-one rule (also known as the K1 rule) to  
39 determine the factors to be included in the model: the eigenvalue of a factor represents the amount  
40 of variance of the variables accounted for by that factor: the lower the eigenvalue, the less that  
41 factor contributes to the explanation of variances in the variables (Norris & Lecavalier, 2010).  
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44 Usually, factors with eigenvalues greater than one are deemed to be significant (Zwick & Velicer,  
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1986).

50 Calculation of eigenvalues was performed in SPSS and four factors were found to have  
51 eigenvalues greater than one, explaining 55% of the variance (Table 5).  
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55 **Table 5 Total variance explained**

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9 Finally, we used the pattern matrix to group the 17 CSF variables around the four factors on the  
10 basis of their factor loadings: the factor loadings are the correlation coefficients between the  
11 variables and the factors, indicating the percentage of variance in each variable explained by each  
12 factor. Higher factor loading indicates that a variable is highly correlated with the relevant factor,  
13 allowing the grouping of variables around the main four factors (Table 6).  
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19 **Table 6 Pattern matrix**  
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23 Matching each variable to the factors for which it has the highest factor loading, we could then  
24 suggest the following composition for each factor.  
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- 27 • **Factor 1** includes project management skills, LSS project selection and prioritisation,  
28 organisational infrastructure, tools and techniques, extending Lean Six Sigma to the  
29 supply chain, data-based approach, linking Lean Six Sigma to HR rewards, and project  
30 tracking and review. All these relate to the sphere of managing projects, and we can  
31 thus refer to the factor as 'project management'.  
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- 34 • **Factor 2** includes management commitment, linking LSS to customers, linking LSS to  
35 business strategy, leadership style, communication, and cultural change. All these are  
36 either leadership traits (style, communication, and commitment) or leadership priorities  
37 (linking Lean Six Sigma to strategy and customers): we can thus refer to this factor as  
38 'leadership'.  
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- 41 • **Factor 3** includes the selection of LSS staff and resources for LSS staff. We can refer to  
42 this as 'selection of top talented people'.  
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- 45 • **Factor 4** is about the overall financial accountability of the Lean Six Sigma  
46 programme. We can refer to this as 'financial accountability'.  
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10 Project management, leadership, selection of top talented people, and financial accountability are  
11 the four significant factors for a successful Lean Six Sigma implementation, confirming our initial  
12 hypothesis on leadership being a critical success factor for Lean Six Sigma deployment.  
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## 15 16 **5. Discussion and implications**

### 17 18 **5.1 Implications for practice**

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20 The study presented here draws a more complete picture of the critical success factors for Lean Six  
21 Sigma deployment in organisations: this research adds to the theory of Lean Six Sigma by  
22 highlighting and investigating the role of leadership in driving organisational deployment,  
23 confirming the hypothesis that leadership is indeed a critical success factor for the deployment of  
24 Lean Six Sigma in organisations. The four factors identified as significant all have managerial  
25 implications for the practice of Lean Six Sigma, and provide a solid framework for organisations  
26 about to start deployment:  
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- 35 • Project management: for Lean Six Sigma deployment to be successful, it is important to work  
36 on projects aligned to the business strategy, so as to show immediate value to the organisation at  
37 large. Accurate data-driven tracking of projects is necessary to ensure deployment stays on  
38 track, as well as reward success among employees (Duarte, Montgomery, Fowler, & Konopka,  
39 2012; Kornfeld & Kara, 2013).  
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- 45 • Leadership: as we have seen from the literature review, leaders have many different traits and  
46 styles. These results suggest that successful leadership is:  
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  - 49 • committed to processing improvement in general and Lean Six Sigma specifically, as  
50 suggested by Dale and Lightburn (1992). Lean Six Sigma transformation is a journey  
51 that does not happen overnight: successful leaders are those that can see beyond the  
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difficulties and inspire employees to keep going (Hilton & Sohal, 2012; Jokinen, 2005; Suresh et al., 2012);

- able to see the link between Lean Six Sigma and the overall business strategy and its customers as well as communicate this to employees in a clear and compelling vision (Hilton & Sohal, 2012; Sumukadas, 2006; Suresh et al., 2012);
  - able to establish an organisational culture that accelerates Lean Six Sigma implementation (Taylor & Wright, 2003);
  - and that visible, inspirational, realistic, targeted and consistent leadership is necessary to carry the organisation forward (Kausman & Lane, 2008).
- Selection of top talented staff: although it is rather typical of organisations that the oldest or the most experienced professionals are in positions of leadership (Kulmala, Ahonemi, & Nissinen, 2009), this study highlights the importance of involving the top talent in the organisation in Lean Six Sigma, providing them with the right project management tools and making them financially accountable for the success of their initiatives (Panizzolo, Garengo, Sharma, & Gore, 2012).
  - Financial accountability: it is necessary to keep the Lean Six Sigma efforts linked to the financial results of the organisation, making leaders accountable for the financial impacts of their initiatives.

## 5.2 Implications for research and limitations

Like any research, this study has a number of limitations which present interesting future research opportunities. The study focuses on the impact of leadership on Lean Six Sigma deployment, but it does not go into the specifics of separating the types of leadership needed from senior management versus that needed from middle management: more research is needed to investigate whether there

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7 is any significant difference between the two and their influence on Lean Six Sigma  
8 implementation.  
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11 There is also an opportunity for empirical research to determine which leadership style is most  
12 conducive to successful deployment. Bremer, Daniels, Gupta, and McCarty (2005) suggested that  
13 Six Sigma leadership utilises both transactional and transformational forms of leadership, and  
14 Pande (2007) suggests the need to go beyond these traditional forms of leadership; an empirical  
15 investigation that correlates leadership traits with the success, or lack of success, of the Lean Six  
16 Sigma programme in organisations may be needed to close this gap.  
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23 Future research must also empirically investigate which type of leadership is more appropriate at  
24 different stages of Lean Six Sigma programme maturity: is the leadership style needed to support  
25 the start of such a programme the same as that needed to sustain the same deployment later on?  
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## 32 **6. Conclusion**

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35 Lean Six Sigma is an evolving quality management practice that has attracted both academics and  
36 practitioners thanks to its documented success. It was the objective of this paper to obtain further  
37 insights into Lean Six Sigma deployment, highlighting the more important critical success factors  
38 (CSFs) and particularly the role of leadership in successful deployment. Although many CSFs have  
39 been identified in the Lean Six Sigma literature, few studies have highlighted the role of leadership,  
40 which is key to Six Sigma success (Hoerl & Snee, 2003).  
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47 The study also has broader implications for managers and Lean Six Sigma practitioners who deploy  
48 quality improvement programmes in the hope that these programmes will enhance performance and  
49 outweigh the investment made (Arumugam, 2012): this study highlights the importance of putting  
50 the right leadership in place to ensure successful deployment, coupled with the top talent in the  
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7 organisation involved in Lean Six Sigma, providing them with the right project management tools,  
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9 and making them financially accountable for the success of their initiatives.  
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11 Overall, organisations need to make sure they have in place leaders committed to inspiring  
12 employees and establishing the right culture for continuous improvement in order to reap the benefits  
13 of Lean Six Sigma deployment.  
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For Peer Review Only

Lean	Six Sigma
Both are continuous business process improvement methodologies	
Both focus on business needs defined by the customer	
Both are practical methods, proven to work in many organisations	
Both involve a comprehensive toolkit for tackling process related problems	
Lean is primarily good for quick and initial round of improvements	Six Sigma is suitable for long-term and complex problems where the solutions are either unknown or vaguely known.
Lean requires low investment due to the nature of the training and the skills to be developed as a result of this training	Six Sigma demands high investment and is not suitable for fixing common sense problems in the business
Lean has less emphasis on statistical tools and techniques	Six Sigma requires the use of applied statistical methods for understanding and reducing variation in processes
No formal organizational infrastructure for Lean implementation and deployment	Sigma has a well defined organizational infrastructure (yellow belts, green belts, black belts, master black belts, deployment champions and sponsors in some cases)
Lean looks into mapping of end to end process and uses value stream exercises to understand the interactions between processes	System interaction between processes is not considered in a typical Six Sigma problem solving scenario and this would possibly sub-optimize the overall process performance

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Characteristics	5-Level	Affiliative	Bureaucratic	Participative	Servant	Six Sigma	Transactional	Transcendent	Transformational	Visionary
Ambitious for the organization, not themselves	X				X					
Approachable	X	X		X	X			X		
Challenge the status-quo						X			X	X
Charisma									X	
Charity	X					X	X			
Climate of Trust		X		X				X		
Consensus				X	X			X		
Consistency	X					X				
Contingent Reward							X			
Enthusiastic		X								X
Enthusiasm	X							X	X	X
Exchange							X			
Facilitating dialog and deliberation				X		X		X		
Flexibility	X					X				
Global perspective						X		X		
Goal Orientation	X					X	X			
High-level of control			X				X			
Individual Consideration									X	
Inflexible			X							
Inspiration									X	X
Integrity / Honesty	X				X			X		
Intellectual Stimulation									X	
Manage by Excpetions							X			
Micro-managing			X							
Open-minded						X		X		
Participation		X		X	X			X		X
Personal Humility / Modesty	X									
Promotes Harmony		X								
Protecting & Valuing divergent views				X		X		X		
Quick determination	X					X				
Reflective						X		X		
Relies on inspired standards, not charisma, to motivate	X				X	X				
Service above self					X			X		
Short-term focus			X				X			
Transparency & Disclosure								X		
Understated	X				X					
Unwavering Resolve	X									
Value-Centered					X			X		X
Warmth	X									
Workmanlike diligence	X									

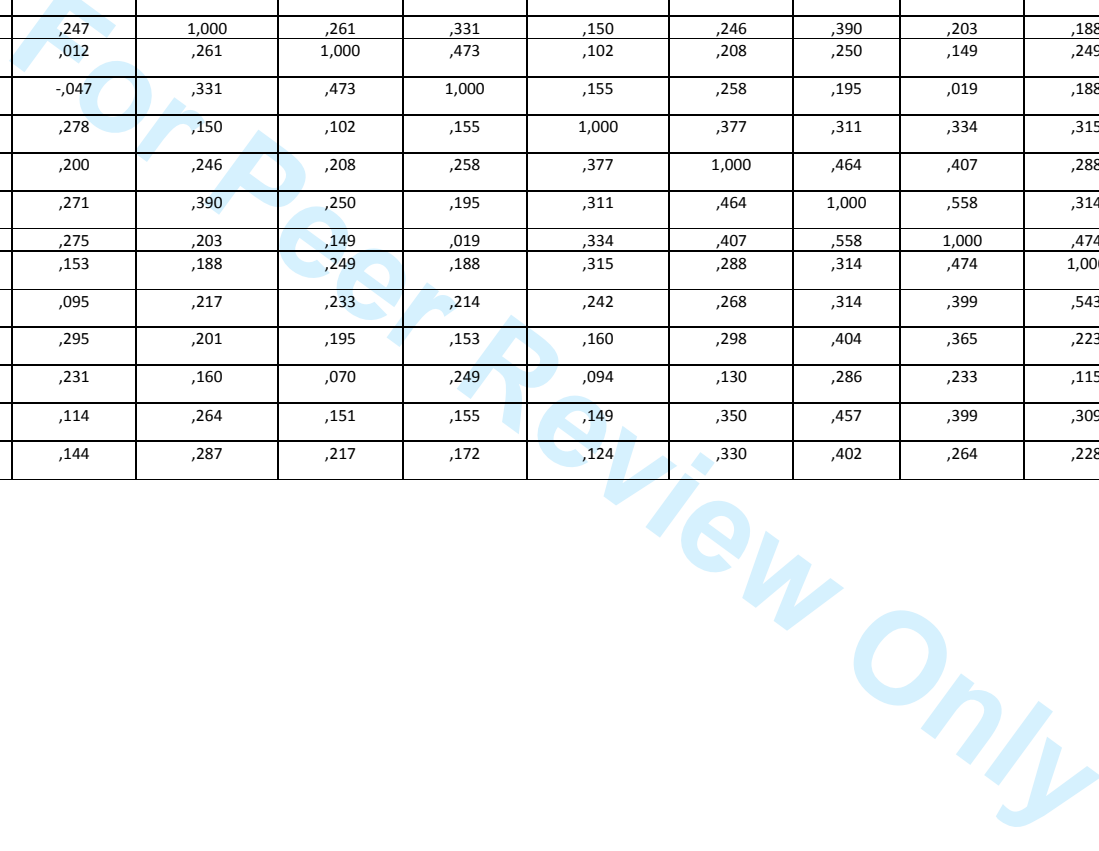
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<b>Leadership Style</b>	<b>Reference</b>
5-Level	Collins, 2001
Affiliative	Goleman, Boyatzis, & McKee, 2004
Bureaucratic	Weber, 1905
Participative	Lewin, Lippitt, & White, 1939
Servant	Greenleaf, 1977
Six Sigma	Pande, 2007
Transactional	Burns, 1978
Transcendent	Gardiner, 2006
Transformational	Burns, 1978
Visionary	Goleman et al., 2004

CSF (R...)	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
Cultural Change				X	X				X		X	X		X	X		X		X						X	X		X		X	
Leadership Style										X	X										X									X	
Management commitment	X		X	X					X		X	X	X	X	X	X	X	X	X						X		X	X	X	X	X
LSS Training		X		X			X		X		X		X	X	X	X			X		X		X	X	X		X	X	X		X
Organization infrastructure						X			X		X	X	X	X		X										X		X			
Communication	X											X																	X		
Linking LSS to business strategy			X	X		X						X	X	X	X		X											X			
Linking LSS to customer												X		X	X		X											X			
Linking LSS to HR rewards	X											X	X	X										X				X	X		
Extending LSS to supply chain			X									X		X														X	X		
LSS projects prioritization				X				X	X		X	X	X	X	X	X					X	X			X			X	X		X
LSS projects tracking and review													X	X			X		X	X	X	X							X		
Project Management Skills				X								X	X	X	X			X		X								X			
Tools and techniques				X					X		X			X	X								X					X			
LSS financial accountability													X	X	X																
Data Based approach									X														X								
Communication and awareness																	X	X	X									X			
Selection of staff for LSS																					X	X									X
Resources to LSS team																							X	X			X			X	

R...	Reference
R1	Henderson & Evans (2000)
R2	Halliday (2001)
R3	Pande et al. (2000)
R4	Eckes (2000)
R5	Erwin (2000)
R6	Dale (2000)
R7	Hendricks & Kelbaugh (1998)
R8	Ingle & Roe (2001)
R9	Harry & Schroeder (2000)
R10	Pande (2007)
R11	Snee & Hoerl (2002)
R12	Coronado & Antony (2002)
R13	Antony et al. (2007)
R14	Antony & Banuelas (2002)
R15	Antony (2006)
R16	Breyfogle et al. (2001)
R17	Burton & Sams (2005)
R18	Hayes (2002)
R19	Sivakumar & Muthusamy (2011)
R20	Revere et al. (2006)
R21	Hahn et al. (1999)
R22	Martens (2001)
R23	Keller (2001)
R24	Brue (2002)
R25	Kwak & Anbari (2006)
R26	Zu et al. (2010)
R27	Kumar (2007)
R28	Brun (2011)
R29	Goldstein (2001)
R30	Achanga et al. (2006)
R31	Johnson & Swisher (2003)

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	Cultural Change	Leadership Style	Management commitment	Organization infrastructure	Communication	Linking LSS to strategy	Linking LSS to customers	Linking LSS to HR rewards	Extending LSS to supply chain	LSS projects selection	Project Mgt skills	LSS Financial accountability	LSS projects tracking	LSS tools & techniques	Data based approach	LSS Staff	Resources to LSS staff
Cultural Change	1,000	,307	,350	,167	,203	,240	,273	,138	,309	,196	,256	,116	,241	,193	,156	,177	,078
Leadership Style	,307	1,000	,457	,105	,259	,368	,324	,044	,384	,266	,147	,139	,181	,268	,148	,077	,174
Management commitment	,350	,457	1,000	,153	,387	,383	,409	,044	,213	,276	,105	,169	,201	,133	,062	,074	,045
Organization infrastructure	,167	,105	,153	1,000	,247	,012	-,047	,278	,200	,271	,275	,153	,095	,295	,231	,114	,144
Communication	,203	,259	,387	,247	1,000	,261	,331	,150	,246	,390	,203	,188	,217	,201	,160	,264	,287
Linking LSS to strategy	,240	,368	,383	,012	,261	1,000	,473	,102	,208	,250	,149	,249	,233	,195	,070	,151	,217
Linking LSS to customers	,273	,324	,409	-,047	,331	,473	1,000	,155	,258	,195	,019	,188	,214	,153	,249	,155	,172
Linking LSS to HR rewards	,138	,044	,044	,278	,150	,102	,155	1,000	,377	,311	,334	,315	,242	,160	,094	,149	,124
Extending LSS to supply chain	,309	,384	,213	,200	,246	,208	,258	,377	1,000	,464	,407	,288	,268	,298	,130	,350	,330
LSS projects selection	,196	,266	,276	,271	,390	,250	,195	,311	,464	1,000	,558	,314	,314	,404	,286	,457	,402
Project Mgt skills	,256	,147	,105	,275	,203	,149	,019	,334	,407	,558	1,000	,474	,399	,365	,233	,399	,264
LSS Financial accountability	,116	,139	,169	,153	,188	,249	,188	,315	,288	,314	,474	1,000	,543	,223	,115	,309	,228
LSS Projects tracking	,241	,181	,201	,095	,217	,233	,214	,242	,268	,314	,399	,543	1,000	,314	,119	,374	,409
LSS Tools & techniques	,193	,268	,133	,295	,201	,195	,153	,160	,298	,404	,365	,223	,314	1,000	,355	,342	,259
Data based approach	,156	,148	,062	,231	,160	,070	,249	,094	,130	,286	,233	,115	,119	,355	1,000	,250	,119
Selection of LSS Staff	,177	,077	,074	,114	,264	,151	,155	,149	,350	,457	,399	,309	,374	,342	,250	1,000	,563
Resources to LSS Staff	,078	,174	,045	,144	,287	,217	,172	,124	,330	,402	,264	,228	,409	,259	,119	,563	1,000

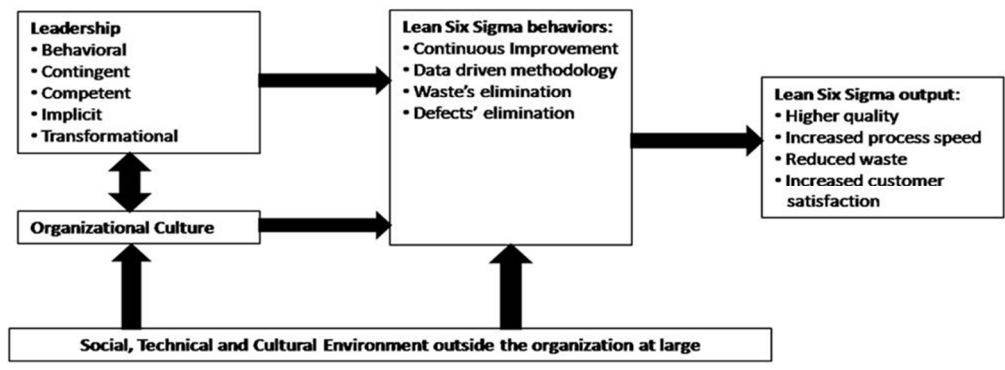


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Factors	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings
	Total	% Variance	Cum %	Total	% Variance	Cum %	Total
1	4,959	29,173	29,173	4,309	25,350	25,350	3,018
2	1,901	11,183	40,355	1,241	7,297	32,647	2,821
3	1,287	7,572	47,927	,950	5,590	38,237	2,351
4	1,172	6,896	54,823	,697	4,103	42,340	2,330
5	,962	5,657	60,481				
6	,904	5,319	65,799				
7	,867	5,102	70,901				
8	,775	4,560	75,462				
9	,697	4,102	79,564				
10	,622	3,658	83,223				
11	,553	3,250	86,473				
12	,484	2,849	89,322				
13	,465	2,738	92,060				
14	,399	2,346	94,406				
15	,341	2,006	96,412				
16	,318	1,872	98,285				
17	,292	1,715	100,000				

	Factor			
	1	2	3	4
Project Management Skills	.611	-.143		-.378
Lean Six Sigma Project Selection / Prioritization	.596	.106	.219	
Organizational Infrastructure	.464			
Lean Six Sigma tools & techniques	.426		.134	
Extending Lean Six Sigma to Supply Chain	.393	.201	.155	
Data-based approach	.355			
Linking Lean Six Sigma to HR rewards	.311			-.272
Management Commitment		.717	-.147	
Linking Lean Six Sigma to Customers	-.148	.674		
Linking Lean Six Sigma to Business Strategy	-.113	.588		-.136
Leadership style	.127	.582		
Communication	-.187	.387	.170	
Cultural Change	.231	.384		
Resources to Lean Six Sigma staff			.893	
Selection of Lean Six Sigma staff	.243		.537	-.118
Lean Six Sigma Financial Accountability				-.815
Lean Six Sigma Project tracking and review		.126	.251	-.544
Extraction Method: Maximum Likelihood. Rotation Method: Oblimin with Kaiser Normalization.				
a. Rotation converged in 12 iterations.				

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Model of leadership, culture and Lean Six Sigma, adapted from Waldman, 1993

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