Lean Six Sigma Maturity Model within Saudi Arabian Organisations:

An Empirical Study

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Abstract

Lean Six Sigma (LSS) is a continuous improvement methodology that aims to reduce the costs of poor quality, improve the bottom-line results and create value for both customers and shareholders. LSS has been deployed in organisations in the Western countries for more than two decades. However, its implementation in Middle Eastern countries has only just begun to emerge. Furthermore, there is a lack of empirical studies in the area of understanding the current status of LSS in these countries. Therefore, the purpose of this research is to investigate the current status of Lean Six Sigma (LSS) in Saudi Arabian organisations and subsequently develop a Lean Six Sigma Maturity Model (LSSMM) which can be used to assess their current level of LSS maturity. The study is based on a systematic literature review of 45 papers that were published on LSS in high ranking journals in the field and other specialist journals, from 2000 to 2015. LSS themes identified include: LSS benefits, critical success factors, motivational factors, tools and techniques, critical failure factors, and limitations. A descriptive survey via a questionnaire was conducted in the second phase of the data collection process and multiple case studies were conducted in the third phase. Based on the literature review and the findings of the empirical research, a LSSMM was developed and used to assess the current level of LSS deployment maturity in five organisations in Saudi Arabia. The results of the empirical study show that LSS is in the early stages of implementation and that organisations in Saudi Arabia have only recently started to recognise the importance of LSS to their business. This finding was also supported by the evaluation of LSS maturity level that was assessed using the model developed in this study. This study contributes to understanding the current status of LSS in Saudi Arabian organisations and provides recommendations to guide the future of LSS in Saudi organisations by comparisons with the LSS literature and best practice. The contribution to knowledge and theory in this study is through validating and extending current operations management theories to LSS deployment, including organisational learning theory, theory of motivation and goal theory. The adoption of a mixed method approach contributes to the advancement of the methodology applied within LSS research in Saudi Arabian organisations. This study adds value for academics and practitioners in the field of LSS in Saudi Arabia by providing an intensive study on the current status of LSS deployment together with the LSSMM.

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List of Publications During the Doctoral Study

1. Journal publications

- **Albliwi, S.,** Antony, J., Arshed, N. and Ghadges, A. (2017), 'Implementation of Lean Six Sigma in Saudi Arabian Organisations: Findings from a Survey', *International Journal of Quality & Reliability Management*, Vol.34 No.4, (Forthcoming).
- Svensson, C., Antony, J., Ba-Essa, M., Bakhsh, M., and **Albliwi, S.** (2015), 'A Lean Six Sigma program in higher education', *International Journal of Quality & Reliability Management*, Vol. 32 No. 9 pp. 951 – 969.
- **Albliwi, S.,** Antony, J., and Lim, S.A. (2015), 'A Systematic Review of Lean Six Sigma for the Manufacturing Industry', *Business Process Management Journal*, Vol.21 No. 3, pp. 665-691.
- **Albliwi, S.,** Antony, J., Lim, S. and Ton van der Wiele, (2014), 'Critical failure factors of Lean Six Sigma: a systematic literature review', *International Journal of Quality & Reliability Management*, Vol. 31 No. 9, pp.1012 – 1030.
- Abdul Halim Lim, S., Antony J., Arshed, N. and **Albliwi, S.** (2015), 'A systematic review of Statistical Process Control Implementation in the Food Manufacturing Industry', *Total Quality Management and Business Excellence,* (Forthcoming).
- Lim, S.A.H., Antony, J., **Albliwi, S.,** (2014), 'Statistical Process Control (SPC) in the Food Industry- A Systematic Review and Future Research Agenda', *Trends in Food Science & Technology*, Vol. 37 No.2, pp.137-151.
- Karaminas, H., Antony, J., Lim, S.A. and **Albliwi, S.A**. 'Six sigma black belt roles and selection criteria: Comparing literature and practitioners' views', *Coach*, Vol.18 No.21, pp.2.

2. Conference Publications

- **Albliwi, S.**, and Antony, J. (2016), 'A Critical assessment of the Current Status of Lean Six Sigma within Saudi Arabian Organisations: Findings from multiple Case Studies'. Proceedings of the Sixth International Conference on Lean Six Sigma, May 30-31, 2016, Edinburgh, UK, Heriot-Watt University.
- **Albliwi, S.**, Antony, J. and Arshed, N. (2015), 'An Empirical Study on Lean Six Sigma in Saudi Arabian Organisations'. Proceedings of the European Operations Management Association (EurOMA), 26 June - 1 July 2015, Neuchâtel, Switzerland.
- Karaminas, H., Antony, J., Lim, S.A. and **Albliwi, S.A**. (2014), 'Six Sigma Black Belt Roles & Selection Criteria: Comparing Literature and Practitioner's Views'. Submitted to The 18th Multi-conference on Systemics, Cybernetics and Informatics: WMSCI.
- **Albliwi, S.A**, Antony, J. and Arshed, N. (2014), 'Critical Literature Review on Maturity Models for Business Process Excellence'. Proceedings of the IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), December 9-12, 2014, Selangor, Malaysia.
- **Albliwi, S**. and Antony, J. (2013), 'Implementation of Lean Six Sigma Approach in the Manufacturing Sector: A Systematic Literature Review'. Proceedings of the 11th

International Conference on Manufacturing Research (ICMR), September 19-20, 2013, Cranfield, UK, 431- 436. Cranfield University.

3. Posters

- **Albliwi, S**., Antony, J., and Mendibil, K. (2013), 'Implementation of Lean Six Sigma Approach in the Manufacturing Sector: A Systematic Literature Review'. Proceedings of the Research Presentation Day, June 27th, 2013, Glasgow, UK. University of Strathclyde.
- **Albliwi, S**., Antony, J., and Mendibil, K. (2013), 'Implementation of Lean Six Sigma Approach in the Manufacturing Sector: A Systematic Literature Review'. Proceedings of 7th Saudi Students' Conference, February 1st – 2nd, 2014, Edinburgh, UK.

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List of Abbreviations

ASQ	American Society for Quality
ANOVA	Analysis of Variance
BB	Black Belt
BQF	British Quality Foundation
BPR	Business Process Reengineering
BPM	Business Process Management
BPMM	Business Process Maturity Model
CI	Continuous improvement
CSFs	Critical success factors
CFFs	Critical failure factors
CMM	Capability Maturity Model
CMMI	Capability Maturity Model Integration
DMAIC	Define-Measure-Analyse-Improve-Control
DOE	Design of Experiments
DMEDI	Define-Measure- Explore- Develop- Implement
DOD	Department of Defense
DMADOV	Define-Measure-Analyse-Design-Optimise-Verify
DFSS	Design for Six Sigma
ERP	Enterprise Resource Planning
EFQM	European Foundation for Quality Management
FMEA	Failure Mode and Effect Analysis
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GB	Green Belt
HR	Human Resources
IT	Information Technology
IS	Information system
IDOV	Identify-Design-Optimise-Validate
KSA	Kingdom of Saudi Arabia
KAQA	King Abdulaziz Quality Award
LO	Learning organisation
LSS	Lean Six Sigma
LSSMM	Lean Six Sigma Maturity Model
MSA	Measurement System Analysis
MBB	Master Black Belt
MBNQA	Malcolm Baldrige National Quality Award
NVA	Non-value-added
OMG	Object Management Group
OL	Organisational learning
PDCA	Plan-Do-Check-Act
QFD	Quality Function Deployment
QMMG	Quality Management Maturity Grid
ROI	Return On Investment
R&D	Research and development
SIPOC	Supplier-Input-Process-Output-Customer
SMED	Single-Minute Exchange of Die
SPC	Statistical Process Control
SMEs	Small and medium-sized enterprises

SQC	Saudi Quality Council
SASO	Saudi Standards, Metrology, and Quality Organization
SSQ	Saudi Society for Quality
SEI	Software Engineering Institute
SPSS	Statistical Package for the Social Science
TPS	Toyota Production System
TOC	Theory of Constraints
TPM	Total Productive Maintenance
TQM	Total Quality Management
VSM	Value Stream Mapping
WB	White Belt
WTO	World Trade Organisation
YB	Yellow Belt

CHAPTER ONE
Introduction

1.1 Introduction

In recent years, Lean and Six Sigma (LSS) have become the most popular business strategies for deploying continuous improvement (CI) in manufacturing and non-manufacturing organisations, including financial services, health care and higher education, in both public and service sectors (Snee, 2010; Snee and Hoerl, 2003). CI is the main aim for any organisation, to help to achieve quality and operational excellence (Assarlind et al., 2012; Timans et al., 2012) and to enhance performance (Antony et al., 2012b; Thomas et al., 2009). Lean has been widely used in Japan since 1990 to eliminate waste and non-value-adding activities in the process anywhere in the company, and to change the culture and ensure customer satisfaction (Karim and Arif-Uz-Zaman, 2013; Womack et al., 1990). In contrast, Six Sigma emerged in the USA in the 1980s with the main aim to reduce variation in any process, in order to improve process performance, reduce costs in manufacturing and services and make savings to the bottom-line, as well as increasing customer satisfaction (Harry and Schroeder, 2000; Snee and Hoerl, 2003). However, deploying Six Sigma in isolation cannot eliminate all types of waste from the process, and deploying the Lean approach in isolation cannot control the process statistically and remove variation (Corbett, 2011; Salah et al., 2010; Yi et al., 2012). Instead, it requires the integration of these two approaches to make the organisation more efficient and effective and help it to achieve superior performance at a faster pace than could be obtained through the implementation of each approach in isolation (Antony et al., 2012b; Salah et al., 2010). Examples of world-class companies that have successfully deployed Lean Six Sigma (LSS) include GE, Motorola, Johnson & Johnson, Allied-Signal (Honeywell), Bank of America and Cummins (Laureani and Antony, 2012; Snee, 2010; Snee and Hoerl, 2003, 2005). However, all these companies are based in Western countries, while there is no evidence regarding the current level of LSS implementation in Arab countries, apart from 15 case studies published by Saudi Arabian firms, which is the highest number of publications on this subject across Arab countries.

This lack of evidence prompted the researcher to begin searching for organisations in Arab countries which have implemented Lean Six Sigma. Of particular interest were organisations in Saudi Arabia, as the largest and one of the richest countries in the Middle East, to find out what would motivate them to implement this method. If organisations within Saudi Arabia have implemented Lean Six Sigma, is the implementation as mature as in some Western countries? Are these organisations deploying organisational learning practices in order to support and improve Lean Six Sigma? These and many other questions emerged, which created the desire to undertake a PhD in Lean Six Sigma within the Saudi Arabian context. A search in the literature was undertaken to explore studies that could answer the questions raised about the current level of Lean Six Sigma adoption within Saudi Arabian organisations. Unfortunately, there was only one paper, by Alsmadi et al. (2012), which investigated the current status of Six Sigma in 100 Saudi organisations using a survey technique. Although 15 other papers were found, these were each based on a single case study in different industries, indicating a lack of depth in research and knowledge reflecting the current level of LSS deployment across the country.

Thus, there appears to be a gap in the recent literature concerning the current level of LSS adoption and the level of LSS maturity in Saudi Arabia, as pointed out by Almuharib (2014) and Alsmadi et al. (2012). Moreover, although implementation of LSS in Arab countries is still less popular than in countries in the west, and even a new concept in some countries, searching the literature revealed a lack of research in LSS implementation in Arabian organisations. It was hard even to find any research describing the current level of LSS implementation in Arab countries, or at least a method to measure the deployment level.

Thus, in order to address the gap in the literature, the researcher has conducted an empirical study, using both survey and case study techniques, to collect more facts about the issues involved in the adoption and deployment of LSS in the Saudi Arabian context. The main aim of this study was to assess the current level of Lean Six Sigma adoption in Saudi Arabian organisations and to develop a Maturity Model for Lean Six Sigma to help Saudi Arabian organisations to assess their level of Lean Six Sigma maturity.

This chapter introduces the background to the study and outlines the key research gaps to be investigated and the structure of the following chapters.

1.2 Research context

The Kingdom of Saudi Arabia (KSA) is located in the heart of the Middle East with population of more than 30 million (GAS, 2015). Due to the efficient use of resources, and oil in particular, the KSA is recognised as one of the top 15 highly stable and dynamic economies in the world (Al-Darrab et al., 2013; Albassam, 2015). There are a huge number of organisations in the KSA, with a total 1,805,875 organisations, according to the last statistical report in 2015, by the Ministry of Commerce and Investment. The vast majority are small organisations, with only 24,297 medium sized organisations and 3,780 large and multinational organisations (MCI, 2015). However, the contribution of the small and medium-sized enterprises (SMEs) is only around 37% of the Gross Domestic Product (GDP), which is considered low compared to other countries in the region (MCI, 2015). For instance, in the United Arab Emirates there are around 350,000 SMEs, which contributed 60% of the GDP in 2015 (MOE, 2015). Moreover, according to the most recent statistical report by the Ministry of Commerce and Investment (MCI, 2015), around 30% of the SMEs in KSA had stopped doing business in 2015, due to lack of management experience and financial problems caused by the lack of funding bodies to support this sector. On the other hand, large and multinational corporations contributed 58.7% to the GDP in 2015 (MCI, 2015). The large number of organisations in the KSA indicates that it is difficult to inspect or test the quality of all the products and services provided by these organisations, emphasising the need for doing things right the first time.

Controlling the quality of products and services has become the first priority for the KSA since the kingdom joined the World Trade Organisation (WTO) in 2005, which allows international firms to import high quality products to the Saudi market (Alsaleh, 2007; Alsmadi et al., 2012). Another reason for the importance of improving quality is the pressure that comes with Foreign Direct Investment (FDI) in Saudi Arabia. FDI has many benefits to the Saudi economy, such as creating jobs for Saudi young citizens, which will reduce the unemployment rate, and contribute to the GDP of the kingdom (Albassam, 2015; Alsaleh, 2007). A newly emerged reason is the national vision announced in April 2016, aiming to increase the sources of income by creating job opportunities and bringing about a real change in the kingdom. All these long-term improvement plans need continuous improvement and higher quality in less time and with fewer resources (Vision, 2016).

Although many quality assurance societies and authorities have been established by the government, controlling quality is still seen as a major challenge across different organisations in the country and many organisations are struggling to survive (Alsaleh, 2007; Magd, 2006). Using ISO standards or using basic quality improvement tools such as cause and effect analysis, check sheets or control charts might be not adequate, as ISO is only intended as a minimum international standard for a quality system for organisations (Magd, 2006). Instead, a more advanced, holistic approach across the organisation is required to eliminate different types of waste, reduce defects in the process, improve quality of products/services, improve customer attraction, satisfaction and loyalty and enhance the bottom-line results (Hu et al., 2008; Karthi et al., 2014; Salah et al., 2010).

Although Lean Six Sigma is widely used for these purposes across different sectors and countries (George et al., 2005; Snee, 2010; Thomas et al., 2008) the level of LSS adoption in Saudi organisations is unknown, as yet. Additionally, there is an absence of a maturity model that could help Saudi Arabian organisations to assess their level of Lean Six Sigma maturity. In this research, the key gap observed was the deficiency of in-depth studies that have empirically assessed the current situation of Lean Six Sigma in Saudi Arabia in terms of specific aspects such as training and infrastructure, the effect of organisational culture on LSS, factors that are critical for LSS success, and the number of successful projects and common challenges. The factors that motivate organisations to deploy LSS and learning organisation practices, such as learning from other organisations, sharing knowledge regarding LSS and learning from competitors, are strongly connected to both the status of LSS (Antony and Desai, 2009; Nonthaleerak and Hendry, 2008) and the maturity level (Watson-Hemphill and Bradley, 2012), as shown in Figure 1.1. It is, therefore, important to investigate the motivational factors for LSS deployment in Saudi organisations, as well as the most common learning practices.

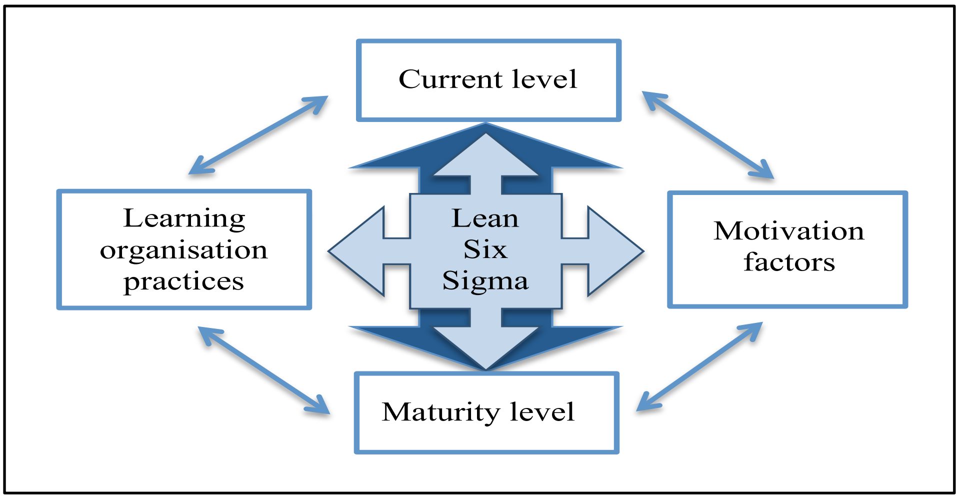

Figure 1.1: Research context

Thus, the research has been designed to describe the current level of Lean Six Sigma implementation in Saudi Arabian organisations, which is assessed using a Lean Six Sigma maturity model.

1.3 Research aims and objectives

The main aim of the research is to assess the current level of Lean Six Sigma adoption in Saudi Arabian organisations and to develop a maturity model for Lean Six Sigma that can help Saudi Arabian organisations to assess their level of Lean Six Sigma maturity.

Based on the research aim, the research objectives are:

1- To assess the current level of Lean Six Sigma adoption in Saudi Arabian organisations.
2- To understand motivational factors for Lean Six Sigma deployment in Saudi Arabian organisations.
3- To assess the maturity level of Lean Six Sigma in Saudi Arabian organisations by developing a maturity model designed specifically for Saudi organisations, based on the literature review and empirical study.
4- To assess the extent to which the participating organisations can be described as learning organisations in the context of Lean Six Sigma.

1.4 Research questions and scope

In order to achieve the overall aim of this research, the following research questions were posed, arising from a careful review of the literature, which is presented in Chapter 2.

RQ1: What is the current level of adoption of Lean Six Sigma in Saudi Arabian organisations?

The first step in this study was to determine the level of Lean Six Sigma adoption in Saudi Arabian organisations. Because of the dearth of existing studies in this area, the level of Lean Six Sigma was determined by using a descriptive survey and case study techniques. It was considered important to understand certain factors influencing the implementation of LSS in the organisations, which included the turnover of the organisation and the number of employees holding LSS Yellow, Green or Black Belts and other LSS certification. It was also important to investigate the number of Lean /Six Sigma projects conducted in the organisation, the level of LSS awareness, investment in LSS training, and many other characteristics, which were derived from the intensive systematic literature review reported in Chapter 2.

RQ2: What are the motivational factors for Lean Six Sigma deployment in Saudi Arabian organisations?

This research question is aimed to explore the relationship between LSS implementation and the motivation behind adopting LSS in the Saudi organisations. The researcher aims here to compare the findings from the literature review and the findings of the empirical research in this study to help to identify which of the motivating factors that emerge are specific to Saudi organisations. Motivation has been found to be one of the main categories in assessing LSS maturity in the previous models used for assessing the level of LSS. Therefore, employees' self-motivation (intrinsic motivation) was also investigated, using the case study technique, and the results were linked to the theory of motivation.

RQ3: How can the maturity level of Lean Six Sigma in Saudi Arabian organisations be effectively assessed?

This question addresses the most important aspect of the research: How can Saudi Arabian organisations effectively assess their LSS maturity level? The maturity state was assessed across six categories identified from the literature and empirical research. The starting point to answer this question was to review and analyse the previous maturity models which were developed in different fields, such as software - the core of maturity models - and in management, particularly in operations management and Lean /Six Sigma. Other models, including unpublished models developed by world-class organisations, were also used, together with the empirical study.

RQ4: To what extent can Saudi Arabian organisations participating in the case study be considered as learning organisations in the context of Lean Six Sigma?

Due to the strong relationship between maturity models and the learning organisation, as well as the relation between LSS and the learning organisation, the final research question is designed to shed light on the applicability of the learning organisation activities listed in the literature to the organisations under study. These activities include learning from mistakes and failed projects, learning from other organisations and transforming knowledge (Garvin et al., 2008; Hines et al., 2004; Manville et al., 2012; Savolainen and Haikonen, 2007; Schroeder et al., 2008; Watson, 2001). In fact, the application of learning organisation practices leads to a high level of LSS maturity. Hence, this research question aimed to explore the extent of learning practices in the targeted organisations using case study techniques and the results were linked to organisational learning theory.

These research questions were formulated to understand the Saudi Arabian approach for deploying LSS as a strategy for continuous improvement. Hence, the questions have been narrowed down from Saudi Arabian organisations to Lean Six Sigma deployment in these organisations. The research has then been focused to develop a maturity model, using the findings of the first two questions. Finally, the focus of the research has been further narrowed to explore some important theories that are related to the building of the maturity model and work as elements in the model, which are organisational learning practices, and motivational factors, as shown in Figure 1.2.

Figure 1.2: Narrowing down the research questions and scope

1.5 Research approach

The research approach presented in Figure 1.3 shows the main research activities, which started with a systematic literature review of LSS and maturity models. The review also focused on the theoretical side of the research, by investigating the motivating factors and organisations' learning practices. The review allowed the researcher to develop a conceptual understanding of the key themes associated with LSS implementation, such as critical success factors, the benefits and challenges of implementation, tools and techniques. Finally, it enabled the research gaps to be identified; this led to the formulation of RQ2, RQ3 and RQ4 and to developing an agenda for future research.

The literature review was followed by data collection, through the use of a mixed method approach of a quantitative survey and qualitative case studies in Saudi Arabian organisations. Following the data collection, the data was analysed (in Chapters 4, 5 and 6) and a conceptual Lean Six Sigma maturity model was developed (Chapter 7). The model was then validated by 14 LSS experts working in Saudi organisations. The final model was then used to assess the level of LSS maturity in 5 organisations located in Saudi Arabia.

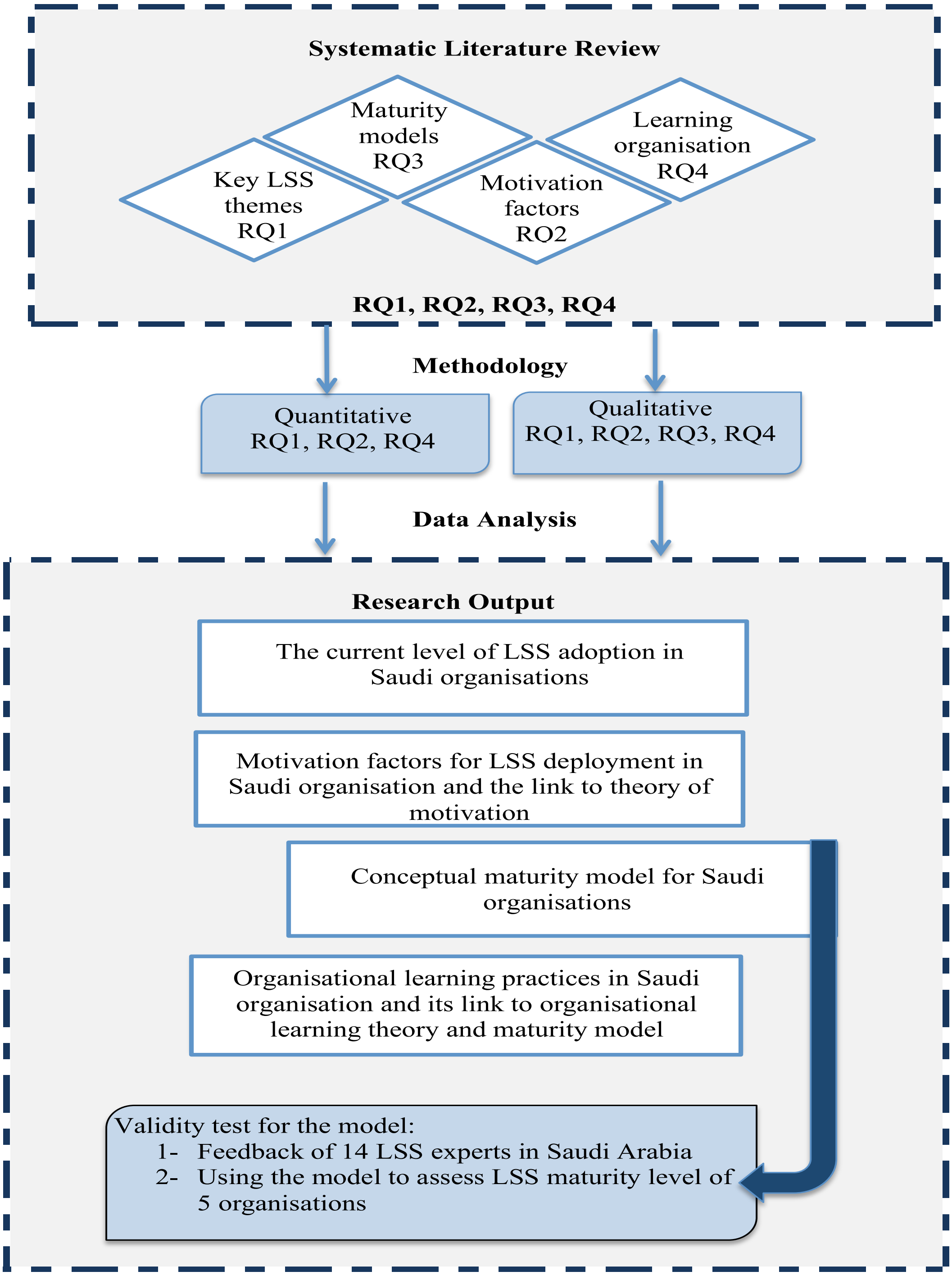

Figure 1.3: Research approach

1.6 Structure of the thesis

This thesis has been divided into nine chapters, as follows:

Chapter Two: Systematic Literature Review of Lean Six Sigma and Maturity Models

This chapter contributes to shedding light on the available Lean Six Sigma literature and leads to identifying the research gaps, thus developing the key research questions for this study. The chapter presents two systematic reviews, first a review of the available literature on LSS as a holistic approach, and then a review of the available maturity models in the literature, in order to develop a Lean Six Sigma maturity model for Saudi Arabian organisations. This is followed by an overview of quality practices that have been reported in Saudi Arabian organisations to date. A review of the operations management theories that support this research is also presented at the end of this chapter.

Chapter Three: Research Design and Methodology

The aim of this chapter is to present the research philosophies, methods and techniques that were chosen to achieve the research aim. This includes a detailed discussion of the data collection process and the analytical techniques employed. Throughout the chapter, the rationale behind these methodological choices is explained.

Chapter Four: Survey Data Collection and Analysis

This chapter is based on a descriptive survey questionnaire derived from two systematic literature reviews published in IJQRM (Albliwi et al., 2014) and BPMJ[1] (Albliwi et al., 2015). The purpose of the survey was to critically assess the current status of Lean Six Sigma implementation in Saudi Arabian organisations, investigate motivational factors for Lean and Six Sigma deployment, and investigate the organisational learning practices that support LSS in Saudi organisations. This chapter presents the response rate, key findings from the survey, including demographic information about participants, the history of quality practices in the participating organisations, and an overview of the current status of LSS in Saudi Arabian organisations.

Chapter Five: Within-Case Analysis

The purpose of this chapter is to present the findings from five case studies undertaken in organisations in Saudi Arabia. It begins by presenting the background and demographic information for the case organisations (referred to as A, B, C, D and E) before addressing the characteristics that shape the current status of Lean Six Sigma in these organisations, including infrastructure, level of training, benefits generated, commonly used tools and techniques, organisational culture and critical success factors. These characteristics have been combined into themes which form the second unit of analysis. The findings from this chapter

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[1] Albliwi, S., Antony, J., and Lim, S.A. (2015), 'A Systematic Review of Lean Six Sigma for the Manufacturing Industry', Business Process Management Journal, Vol.21 No. 3, pp. 665-691.
Albliwi, S., Antony, J., Lim, S. and Ton van der Wiele, (2014), 'Critical failure factors of Lean Six Sigma: a systematic literature review', International Journal of Quality & Reliability Management, Vol. 31 No. 9, pp.1012 – 1030.

support the findings of the survey in Chapter 4 and contribute to answering the research questions set at the beginning of the thesis.

Chapter Six: Cross-Case Analysis and Findings

The researcher has used both within-case and cross-case analyses, as suggested by Eisenhardt (1989a). Thus, after presenting the first part of the case study analysis (within-case) in Chapter 5, this chapter presents the cross-case analysis. The analysis, which aims to answer research questions 1, 2 and 4, is both case-oriented and variable-oriented (Miles and Huberman, 1994). While the aim of the first approach is to identify recurring patterns, the second seeks to identify recurring themes.

Chapter Seven: Lean Six Sigma Maturity Model for Saudi Arabian Organisations

This chapter presents the main process of developing and validating a maturity model for Lean Six Sigma for Saudi organisations, which is one of the main theoretical and practical contributions of this research. The chapter outlines the main maturity levels, categories and the scoring criteria derived from the systematic literature review and the empirical research. A SWOT analysis is also undertaken to identify the internal strengths and weaknesses of the model, as well as the external opportunities and threats.

Chapter Eight: Discussion of Key Findings

This study was conducted to assess the current level of Lean Six Sigma adoption within Saudi Arabian organisations and thereby develop a maturity model to assess the level of LSS implementation in Saudi organisations. The research gaps and research objectives were identified and presented in Chapter 1 and an empirical study was conducted to achieve the research objectives (see Chapters 4, 5, 6 and 7). This chapter discusses the key findings of the empirical research and maps the results against the literature.

Chapter Nine: Conclusion and Research Contribution

This chapter is the closure of this research and it proposes answers for the main research questions that emerged in Chapter 1. This chapter discusses the quality of the research and presents the main contribution of this study to theory, knowledge and practice. The limitations of this study are also presented, followed by an agenda for future research that can help other researchers in the field to direct their research focus to narrow the gaps in the current literature. Lastly, a critical reflection on the research journey is presented, to reflect on the practices learnt and the personal experiences that the researcher gained, as well as the challenges and barriers faced during the PhD journey.

CHAPTER TWO

Systematic Literature Review of Lean Six Sigma and Maturity Models

2.1 Introduction

This chapter presents two systematic reviews, firstly of the available literature on Lean Six Sigma (LSS) as a holistic approach, and then concerning the available maturity models in the literature, in order to develop a Lean Six Sigma maturity model appropriate for Saudi Arabian organisations. This is followed by an overview of quality practices that have been reported in Saudi Arabian organisations to date. A review of the operations management theories that support this research is also presented at the end of this chapter. These processes, as shown in Figure 2.1, have helped the researcher to identify the gaps in the current literature and make a contribution to both knowledge and theory. As explained in Chapter 1, the key gap found was the absence of in-depth studies that have empirically assessed the current situation of Lean Six Sigma in developing countries and in Saudi Arabia in particular.

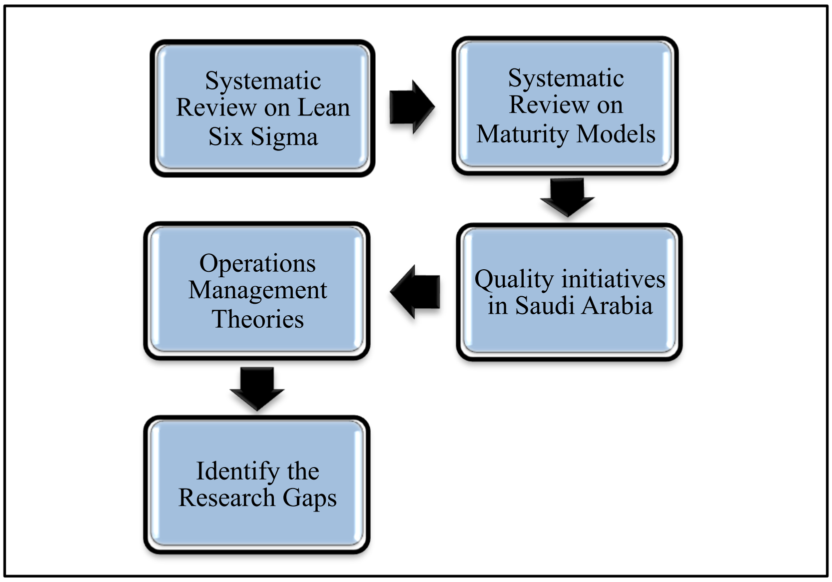


Figure 2.1: Literature review content and processes

In order to get a better understanding of the term Lean Six Sigma as an interactive approach, the researcher believes that Lean and Six Sigma should each first be explained in isolation. Hence, the next two sections are about Lean and Six Sigma strategies separately, followed by a detailed explanation of Lean Six Sigma as one holistic strategy.

2.2 Introduction to Lean

Womack et al. (1990, p.44) define Lean as a "dynamic process of change, driven by a set of principles and best practices aimed at continuous improvement". Another definition for Lean, by Hopp and Spearman (2004, p.141), is "the production of goods or services that minimizes buffering costs associated with excess lead times, inventories, or capacity". However, this definition is more appropriate for Lean Manufacturing, which focuses on product quality and the performance of production lines.

The origin of Lean lies in the Toyota Production System (TPS), which was established shortly after World War II in Japan, by Taiichi Ohno, while he was an employee at the Toyota Motor Company (Maleyeff et al., 2012; Pepper and Spedding, 2010; Womack et al., 1990; Womack and Jones, 2003) to cover the shortage in capital and resources by reducing waste (Pepper and Spedding, 2010; Timans et al., 2012). As a result of the publication of the book "*The Machine that Changed the World: The Story of Lean Production"* by Womack and Jones in 1990, and a study of the Toyota Production System, the TPS has been well recognised and was adopted in the USA and became known in the Western countries as Lean manufacturing (Akbulut-Bailey et al., 2012; Timans et al., 2012).

Lean focuses on elimination of non-value-added (NVA) activities and waste (or "Muda") in industry (Näslund, 2008; Taghizadegan, 2006; Vinodh et al., 2012; Womack and Jones, 2003). Waste can be defined as "everything that increases cost without adding value for the customer" (Dahlgaard and Dahlgaard-Park, 2006, p.267). There are seven types of waste that can be eliminated by using Lean: motion, overproduction, over-processing, lead time, rework, inventory and defects (Bhuiyan et al., 2006; Chakravorty and Shah, 2012; Lee and Wei, 2009; Ohno, 1988; Vinodh et al., 2011). In addition, two more types of waste have recently appeared in the literature: underutilisation of people's creativity, and environmental waste (Vinodh et al., 2012). Lean also focuses on reduction of total cycle time (Drohomeretski et al., 2013; Lee and Wei, 2009) and reduction of lead time (Chen et al., 2010; Hu et al., 2008) by improving material flow and equipment uptime. Furthermore, Lean aims to improve quality by reducing defects and improving the process (Womack and Jones, 2003).

Lean involves the use of many tools and techniques for improvement, such as the Kanban system, 5S (Sort, Straighten, Shine, Standardise and Self-discipline), Cause and Effect analysis (C&E), Single-Minute Exchange of Die (SMED), Value Stream Mapping (VSM), Poka-Yoke, Total Productive Maintenance (TPM), Cellular Manufacturing, Visual Management and many others (Antony et al., 2003; Chakravorty and Shah, 2012; Chen and

Lyu, 2009; Drohomeretski et al., 2013; Kumar et al., 2006; Thomas et al., 2009; Vinodh et al., 2012). However, companies cannot implement the same set of tools and techniques in all cases, so selecting the appropriate ones is critical for Lean success (Karim and Arif-Uz-Zaman, 2013; Shah and Ward, 2003).

The core principles of Lean were introduced by Womack et al. (1990), which are: "1) identification of value, 2) elimination of waste and 3) the generation of smooth flow" (Karim and Arif-Uz-Zaman, 2013, p.172). A few years later, Womack and Daniel (2003, p.25) expanded these principles into five, which are: "1) Identification of customer value, 2) Management of the value stream, 3) Developing a flow production, 4) Using 'pull' techniques, 5) Striving for perfection". Since then, many researchers have modified and grouped these principles, for example, Liker (2004) who presented and grouped 14 principles in four categories, which are philosophy, process, people and problem.

2.3 Introduction to Six Sigma

Six Sigma was defined by Mikel Harry, one of the well-known Six Sigma pioneers, as a "business process that allows companies to drastically improve their bottom-line by designing and monitoring everyday business activities in ways that minimize waste and resources while increasing customer satisfaction" (Harry and Schroeder, 2000, p.VII). Snee, (2004, p.8) defines Six Sigma as "a business improvement approach that seeks to find and eliminate causes of mistakes or defects in business process by focusing on process outputs that are of critical importance to customers".

Both these Six Sigma definitions agree that it is about improving the business processes, in the first stage, to achieve financial results and customer satisfaction. This makes Six Sigma different from other improvement approaches such as TQM. Six Sigma is also different from other approaches in that it integrates the human and process aspects (Snee, 2004).

Six Sigma is a measure of the process capability, with a 6-sigma process having a defect level of 3.4 parts per million opportunities (Harry, 1998). To qualify as a Six Sigma company, an organisation must maintain a perfect score or a near perfect score (99.9997%), free from defects. The expression 6-sigma represents 6 standard deviations on a normal distribution, as shown in Figure 2.2.

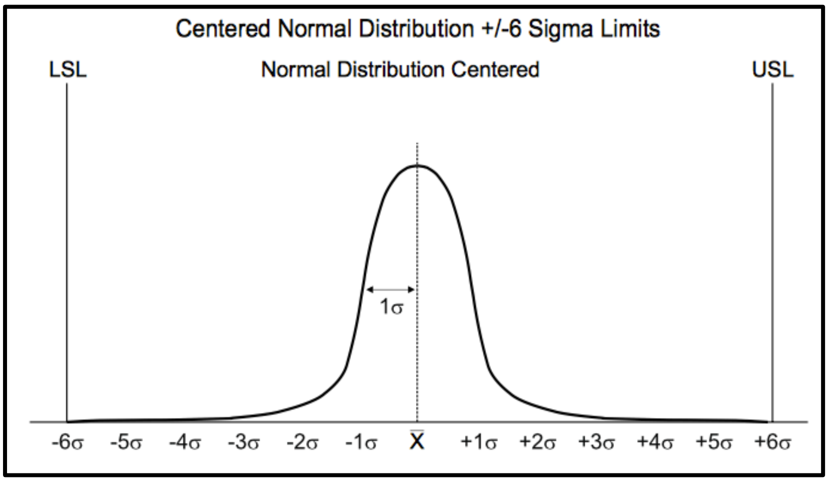


Figure 2.2: Six Sigma Normal Curve
(Source: George, 2003)

Six Sigma methodology was developed by an engineer called Bill Smith at the Motorola Research Centre in the US between 1979 and the early 1980s (Gijoa et al., 2011; Goh, 2010; Harry and Schroeder, 2000; Pepper and Spedding, 2010; Snee, 2010; Snee and Hoerl, 2003; Timans et al., 2012). In 1986, a senior engineer Bill Smith introduced the original statistics and formulae of the Six Sigma methodology. Six Sigma was then recognised as the key approach to address quality concerns (Barney, 2002; Pande et al., 2000) and two years later Motorola won the Malcolm Baldrige National Quality Award (Barney, 2002; Harry and Schroeder, 2000; Snee, 2010; Taghizadegan, 2006).

Six Sigma aims to reduce variation in any process and improve process performance (Banuelas et al., 2005; Chakravorty and Shah, 2012; Näslund, 2008; Snee and Hoerl, 2003); reduce costs in manufacturing and services, make savings to the bottom-line and increase customer satisfaction (Drohomeretski et al., 2013; Gijoa et al., 2011; Goh, 2010; Manville et al., 2012; Näslund, 2008; Snee and Hoerl, 2003; Thomas et al., 2009); improve profits, quality and efficiency (Harry and Schroeder, 2000), measure defects, improve product quality, and reduce defects to 3.4 parts per million opportunities in an organisation (Chen and Lyu, 2009; Lee and Wei, 2009; Vinodh et al., 2012).

The power of the Six Sigma toolbox is the integration of statistical and non-statistical tools and techniques for quality improvement and problem solving under a single framework, DMAIC (Define-Measure-Analyse-Improve-Control), shown in Figure 2.3 (Antony, 2007; Antony and Banuelas, 2002; Snee and Hoerl, 2003).

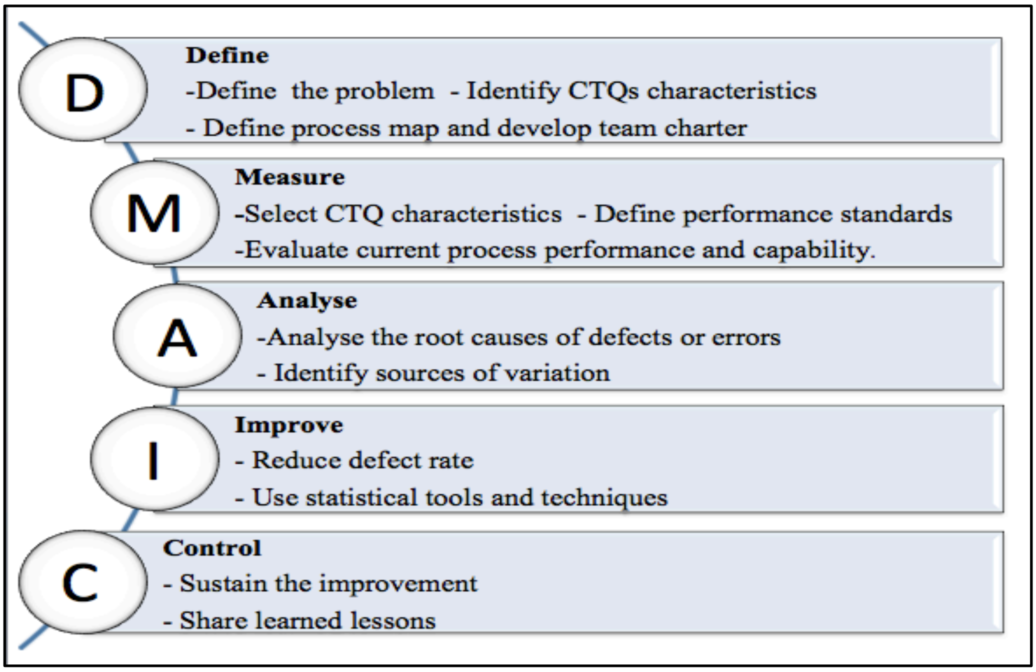


Figure 2.3: Phases of DMAIC Methodology
(Adopted: Salah et al., 2010 and George, 2003)

Six Sigma users can achieve superior results through powerful analytical and statistical tools and techniques, including Quality Function Deployment (QFD), Failure Mode and Effect Analysis (FMEA), Statistical Process Control (SPC), Design of Experiments (DOE), Analysis of Variance (ANOVA), Measurement System Analysis (MSA) and the Kano Model (Antony et al., 2003; Banuelas et al., 2005; Bhuiyan et al., 2006; Goh, 2010).

However, as pointed out earlier, deploying Six Sigma in isolation cannot remove all types of waste from the process, nor can deploying the Lean approach in isolation control the process statistically and remove variation from the process (Corbett, 2011; Salah et al., 2010; Yi et al., 2012). Thus, some companies have decided to merge these CI methodologies, to overcome their weaknesses when implemented in isolation (Antony et al., 2003; Bhuiyan et al., 2006; Taghizadegan, 2006). In fact, Lean and Six Sigma are complementary to each other, and there is an obvious relation between both methodologies, which makes it possible for the synergy of the two methodologies to generate a more powerful strategy for optimising processes: Lean Six Sigma (Hu et al., 2008; Salah et al., 2010).

2.4 Introduction to Lean Six Sigma

In order to answer the research questions, it is important to undertake a comprehensive literature review on the topic of interest. Therefore, the following section will discuss LSS as a holistic approach, including the factors that can be used to assess the current status of LSS in an organisation.

2.4.1 The evolution of Lean Six Sigma

Lean Six Sigma or Lean Sigma is not a completely new approach. As the name "Lean Six Sigma" indicates, it is a combination and synergy between Lean management techniques and Six Sigma methodology (see Figure 2.4) (Chakravorty and Shah, 2012; Hilton and Sohal, 2012; Kumar et al., 2006; Vinodh et al., 2012). The initial integration of Lean and Six Sigma and its subsequent popularity arose in the USA, in the George Group in 1986 (Chakravorty and Shah, 2012; Salah et al., 2010; Vinodh et al., 2012). However, the term Lean Six Sigma was first used in the literature in 2000 (Antony et al., 2012b; Snee, 2010; Timans et al., 2012).

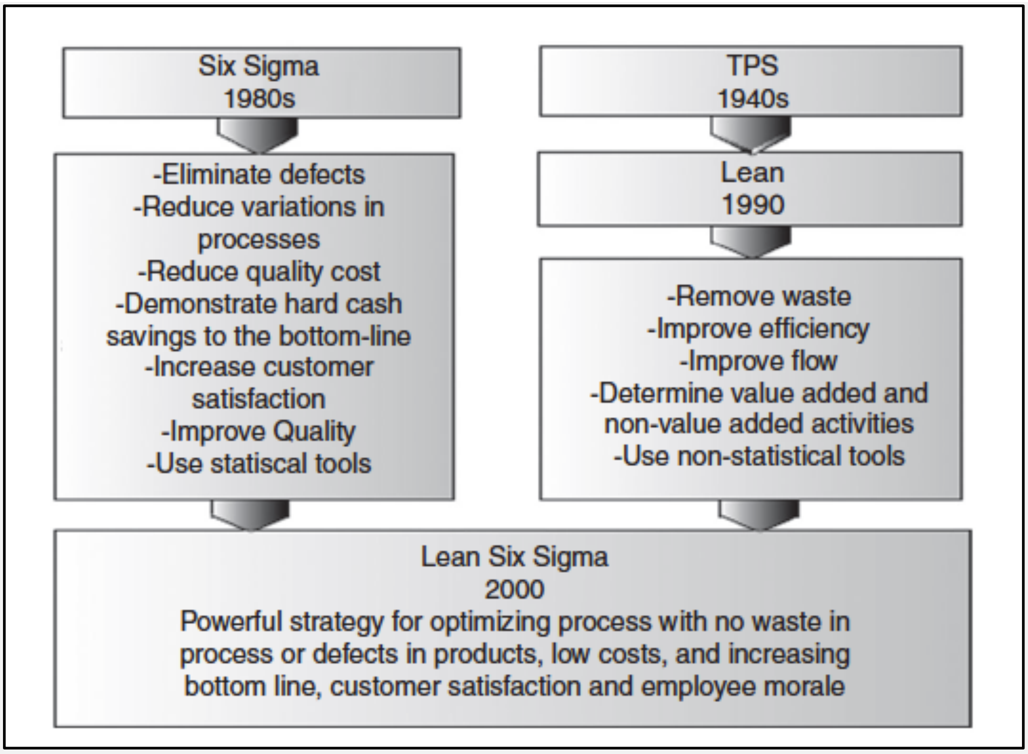


Figure 2.4: Lean and Six Sigma integration
(Adopted from Shahin and Alinavaz, 2008)

LSS teaching was established in 2003, as part of the evolution of Six Sigma (Kubiak, 2011; Timans et al., 2012). Since that time, there has been a noticeable increase in the popularity and deployment of LSS in the industrial world (Gupta et al., 2012; Shah et al., 2008), especially in large Western organisations, such as Motorola, Honeywell, General Electric, Du Pont, Merck, Johnson & Johnson, Bank of America (Laureani and Antony, 2012; Snee, 2010; Timans et al., 2012) and in some small and medium-sized manufacturing enterprises (SMEs) (Antony et al., 2005; Kumar et al., 2006, 2011).

As a result of ideas about the integration of Lean and Six Sigma and the interest in Lean Six Sigma by organisations, more papers have been published on LSS, to try to come up with a comprehensive approach to achieve CI. For instance, a number of academics have developed an integrated strategy (Thomas et al., 2008; Snee and Hoerl 2007; Pepper and Spedding, 2010; Karthi et al., 2011). Other researchers have developed a framework for the successful integration of Lean and Six Sigma, including Salah et al. (2010), Alsmadi and Khan (2010) and Kumar et al. (2006). The benefits and the critical success factors of applying Lean and Six Sigma in parallel have also been reported in many case studies, in both the manufacturing and the service sector (Akbulut-Bailey et al., 2012; Hardeman and Goethals, 2011; Pickrell et al., 2005). However, not all organisations have gained real benefits from LSS, as unsuccessful implementation has sometimes rendered the approach ineffective (Chakravorty, 2009; Glasgow et al., 2010; Jeyaraman et al., 2012; Jeyaraman and Teo, 2010; Kumar and Antony, 2008; Kumar et al., 2007). This failure was found to be due, in some cases, to gaps and limitations in LSS itself that need to be addressed in the LSS research (Albliwi et al., 2014; Chakravorty and Shah, 2012). Hence, this study has attempted to identify those gaps in the current literature regarding Lean Six Sigma research that are most relevant within different sectors.

2.4.2 Lean Six Sigma definitions

LSS was defined by Snee (2010, p.10) as “a business strategy and methodology that increases process performance, resulting in enhanced customer satisfaction and improved bottom-line results.” According to Salah et al. (2010, p.250), LSS is “a methodology that focuses on the elimination of waste and variation, following the DMAIC structure, to achieve customer satisfaction with regards to quality, delivery and cost. It focuses on improving process, satisfying customers and achieving better financial results for the business.” Another definition for LSS was by George (2003, p.6) who defined LSS for services as “A business improvement methodology that maximizes shareholder value by achieving the fastest rate of improvement in customer satisfaction, cost, quality, process speed, and invested capital”.

2.4.3 Lean Six Sigma aims

From the definitions above, it is clear that LSS methodology aims to maximise the value for shareholders by improving quality (Antony et al., 2003; Laureani and Antony, 2012) and capability in an organisation and reducing production costs (Chen and Lyu, 2009; Lee and Wei, 2009). A review of the literature has identified many reasons for organisations to implement an LSS strategy: for example, to improve their business performance and operational efficiency, especially with the growth of global markets (Jeyaraman et al., 2012; Maleyeff et al., 2012). Other reasons are to improve product quality (Vinodh et al., 2012), reduce production costs and to enhance customer satisfaction (Antony, 2007; Antony, et al., 2007; Antony et al., 2012b; Chen and Lyu, 2009; Snee, 2010). Snee (2010) argues that LSS is a powerful strategy for process management and process excellence, which aims to eliminate defects and reduce variation in the processes of service provision and product manufacturing, and leads to business process excellence.

2.4.4 Lean Six Sigma methodology, tools and techniques

More recently, Lean Six Sigma has included the implementation of Six Sigma DMAIC methodology, with a mix of appropriate tools from the Lean and Six Sigma toolkits at each step, as presented in Figure 2.5, where Lean tools are shown in bold (George, 2003; Hilton and Sohal, 2012; Kumar et al., 2006; Thomas et al., 2008; Vinodh et al., 2011).

Moreover, the role of DMAIC in LSS is to act as a framework and a solid base for successful implementation (Chakravorty and Shah, 2012). According to Vinodh et al. (2012) and Salah et al. (2010), LSS tools have the power to help an organisation achieve zero defects. Pickrell et al. (2005) explain that LSS uses the Six Sigma framework as a platform for initiatives, in conjunction with Lean principles and tools, while Snee (2004) points out that the nature of the problem could identify which tools and techniques to use. For instance, Six Sigma is more appropriate when the aim of the project is to reduce process variation or to shift the process average, whereas, Lean would be a better solution for projects aiming to improve process flow or to reduce process complexity.

Figure 2.5 shows the most common Lean and Six Sigma tools and techniques under each phase of DMAIC that helps LSS team to select the right ones when conducting a LSS project. For example, in the Define phase, SIPOC and value stream maps are very common to define the problems that cause customer dissatisfaction. In the Measure phase, there are many common tools/techniques such as Pareto chart, histogram, control charts that have an important role in helping the LSS team to focus on the major causes of the problem. The Analyse phase has a variety of tools and techniques to help the LSS team to map out and explore cause and effect relationships e.g. cause and effect matrix, hypothesis testing, brainstorming. The tools and techniques in the Improve phase are essential to make changes in a process that will eliminate the defects and waste and reduce costs. Examples of these tools and techniques are 5S, Poka-Yoke, FMEA. The final phase is to control the results and ensure that any gains made will be preserved. This can be ensured through tools and techniques which include control charts, visual process control, and process control plans (George, 2003).

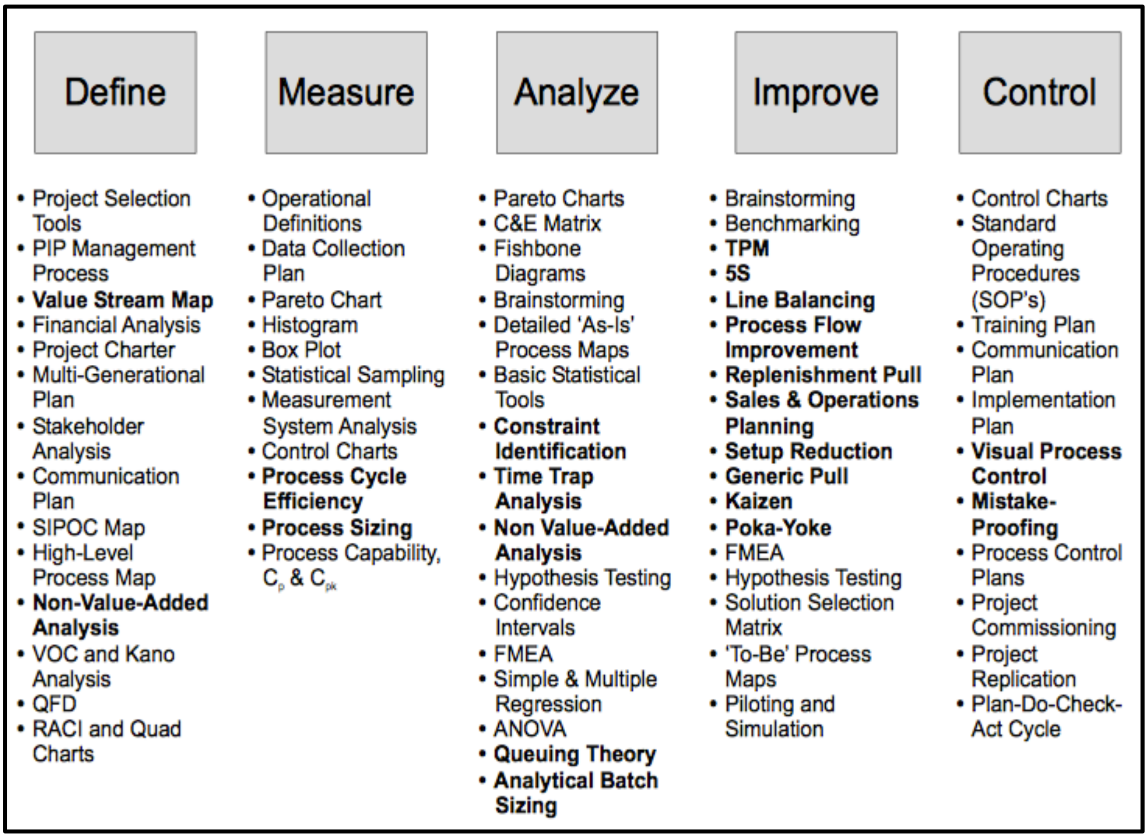


Figure 2.5: Lean Six Sigma DMAIC Tools (Source: George, 2003, P.274)

2.4.5 LSS characteristics

LSS has many characteristics that differentiate it from other improvement initiatives and contribute to LSS success (Snee, 2010). The following section presents the characteristics most closely related to the deployment of LSS and evaluating its current status in an organisation.

2.4.5.1 Leadership

LSS requires a leader who enables an organisation to bring about change in the way the organisation does its work (changing the culture), thus, to move from one paradigm to another paradigm using a top-down approach (Salah et al., 2010). Changing the way of doing the work should be effected through changing the process used to do the work. Therefore, visionary and supportive leadership is considered as one of the critical success factors for LSS projects (Corbett, 2011; Fornari and Maszle, 2004; Laureani and Antony, 2012; Salah et al., 2010; Snee, 2010).

2.4.5.2 Management style

The top-down approach is the most recommended approach for LSS to be successful, as the top management plays an important role in managing the implementation journey. The initiative should cascade from the top level down to lower levels, both to improve the process (Antony, 2011) and to make long-term sustainability more possible (Martin, 2008).

2.4.5.3 Infrastructure and training (the belt system)

The LSS training and belt roles were adopted from the Six Sigma belt system that was introduced by Motorola in 1990, in collaboration with other companies, such as IBM, Texas Instruments and Xerox (Barney, 2002; Mader, 2008). In order to be LSS certified, it is important for the employee to receive training on its tools, techniques and methodologies, plus carrying out a successful project and generating savings, as explained in Table 2.1. The training should create different levels of LSS experts, with the titles created by Motorola, i.e. Champion, Master Black Belt (MBB), Black Belt (BB), Green Belt (GB), Yellow Belt (YB) and the most recently added, White Belt (WB), which is more applicable for SMEs (Bendell, 2006; Laureani and Antony, 2012; Smith, 2003; Snee, 2004, 2010; Taghizadegan, 2006; Voehl et al., 2013).

Table 2.1: Lean Six Sigma belts system

Belt level	Training	Role	Projects and saving/year	Number	Reference
Champion	Receive two to five days training	-Meeting with BB or GB on a weekly basis to remove barriers, provide resources, create infrastructure and leadership for projects -Keep the project focused on the business need and on schedule	No projects or saving required	One project champion required in each department, reporting to the deployment champion in the organisation	Laureani and Antony, 2012; Snee, 2004; Smith, 2003
Master Black Belt	Receive two to five weeks training	-The LSS technical expert -Providing training, coaching, consulting and selecting people for BBs/GBs training and leading critical	No projects or saving required	1 MBB for every 15-20 BBs but LSS can survive without a MBB, where the BBs can	George, 2003; Hoerl, 2001; Laureani and Antony, 2012; Snee, 2004

		projects -Selecting projects and reviewing the completed projects		report directly to the champion	
Black Belt	Receive four weeks training: total of 20 days	-Work full-time on Six Sigma projects. -Lead the project teams and do a considerable amount of the hands-on work -BB has more operational role	-A LSS BB can execute 2 to 3 LSS projects/year -The minimum saving required by a BB is $500k to $1million per year	1 BB for every 100 employees	Breyfogle, 2003; Fornari and Maszle, 2004; George, 2003; Harry, 1998; Harry et al., 2010; Hoerl, 2001; Snee, 2004; Taghizadegan, 2006
Green Belt	Receive two weeks training	Typically do smaller projects in their own work process on a part time basis	-A GB has to execute 2 projects a year -A GB project typically return $25k to $50k per project	5 GBs for every 100 employees	Laureani and Antony, 2012 Harry, 1998; Snee, 2010
Yellow Belt	1 to 5 days depending on the training provider	Involved part-time in LSS projects and can run small process improvement projects, plus their daily job and normal responsibilities	Does not lead projects on his/her own	1 YB for every 5 employees	Assarlind et al., 2013; Laureani and Antony, 2012; Voehl et al., 2013
White Belt	Receive 2 to 4 hours of awareness training	Understands basic LSS concepts, works on local problem-solving teams but may not be part of a LSS project team	Does not lead projects on his/her own	All employees	Antony et al., 2005; George, 2003; Harry and Crawford, 2004; Harry et al., 2010 Kumar et al., 2008

In addition, in order to bring about change in the business and increase profits, the training should be delivered for at least 50% of the organisation's staff (Harry and Schroeder, 2000). Although the training and certification requirement should be similar around the world, the author has noticed clear differences in the belt system between different organisations. The GE belt system presented by Hoerl (2001) requires Black Belts to conduct 5 to 15 financially successful projects, which is not the system followed in Motorola (Laureani and Antony, 2012). However, the LSS training programme depends on the organisation, and most of the large organisations have created their own titles, training programmes and internal certification systems (Taghizadegan, 2006). This could be as a result of a good understanding of their available resources and skills, as suggested by Rowlands, (2004), while SMEs seek help from external consultants to provide training and consultancy (Laureani and Antony, 2012).

2.4.5.4 Projects

Managing LSS projects needs an effective system to integrate Lean and Six Sigma projects as one approach. The recommended system can guide and sustain the initiative by tracking the implementation process of LSS projects, including project reviews, training, communication, and rewards. It has been found that using such a system can guarantee LSS project deployment in 6-12 months (Akkerhuis et al., 2015; Snee, 2010; Snee and Hoerl, 2005).

2.4.5.5 Measures of success

The essential measurements for Six Sigma success are measuring financial saving to the bottom-line and reducing defects, while in Lean, the success is more about reducing waste, *"Muda"*. Therefore, measuring the success of LSS is defined by financial saving to the bottom-line, reducing defects, waste, scrap, and rework, together with improving processes and output quality, and increasing the satisfaction of customers, employees and stakeholders (Snee, 2010). Harry and Schroeder (2000) argue that the company measure what they value and believe is important to measure. Hence, it is very important for companies to find out what they value and how to measure it, so that they can find out how to control their outcomes and improve what they value.

Saving to the bottom-line is one of the important aims in LSS, along with improving quality. Harry (1998) claims that a LSS project could produce a saving of up to $175k, which is a significant saving to the bottom-line. According to Snee (2010), deploying LSS in large organisations can return 1-2% on sales per year, while in SMEs return on sales could reach 3-4% per year. Harry (1998) claimed that, at that time, a BB might save $1m to the organisation's bottom-line in one year. Another technique for measuring financial income is through Return On Investment (ROI). According to Snee (2004, 2010), the return on investment from LSS should be at least 1:5 to 1:8, while Watson-Hemphill and Bradley (2012) estimate that mature LSS deployment can return up to 1:20 to the bottom-line.

2.4.5.6 Changing the culture

Changing the culture is described as changing the way an organisation carries out its work and rewards its employees (Snee and Hoerl, 2003, p.12). Organisations may have different definitions for changing the culture: for instance, it may involve "developing a greater focus on improvement, changing the recognition and reward system, improving the communication system, and improving the performance management system" (Snee and Hoerl, 2003, p.16). However, changing the organisational culture is often a major barrier for LSS implementation, especially in the public sector (Antony and Kumar, 2012).

2.4.5.7 Human resources (HR)

HR has an important role in LSS deployment, in terms of selecting people for training and allocating rewards and bonuses for LSS team members for project success (Antony and Banuelas, 2002). Both Antony and Banuelas (2002) and Salah et al. (2010) argue that it is essential to link HR with LSS to enable the HR reward system to reward LSS members for their efforts and support for the implementation of successful LSS projects. Moreover, the belt system in LSS provides a useful and systematic educational framework, which is a useful tool in human resource management (Antony, 2012).

2.4.5.8 Information technology (IT)

IT resources are also necessary to track Six Sigma projects and enhance the applicability of LSS (Antony, 2012; Sehwail and DeYong, 2003). As the main objective of an IT department is to facilitate business processes throughout the organisation (Svensson et al., 2015), information technology experts can work with the LSS team to support the process (Anand et al., 2010), and also to streamline the processes, and eliminate redundant data entry (Furterer and Elshennawy, 2005).

2.4.5.9 Communication

Developing a communication plan to support LSS deployment is critical for LSS success. This includes communicating the aspects of LSS in a clear and consistent way to all the people in the organisation, from the early stages of the deployment. That means they should be aware of the reason for implementing LSS, its expected benefits, the importance of LSS to the organisation, and its progress. It is a good idea to use the organisation's internal media to make sure that everyone has an idea about the new initiative (Snee and Hoerl, 2005).

2.5 Systematic literature review on Lean Six Sigma

According to Okoli and Schabram (2010, p.1), a systematic literature review is "a systematic, explicit, comprehensive and reproducible method for identifying, evaluating and synthesizing the existing body of completed and recorded work produced by researchers, scholars and practitioners.” Tranfield et al. (2003) suggest that systematic review has become a “fundamental scientific activity.”

One of the advantages of undertaking the systematic review approach is becoming aware of the breadth of research and the theoretical background in a specific field. It is very important to conduct a systematic review in any field, to understand the level of previous research that has been undertaken and to identify the weaknesses and areas that need more research in the field (Okoli and Schabram, 2010). To date, a number of systematic reviews have been undertaken regarding Six Sigma, such as Brady and Allen (2006), Nonthaleerak and Hendry (2006), Tjahjono et al. (2010), and also regarding Lean, for example, Stone (2012). However, only two systematic reviews of LSS, have been published, which were carried out by Glasgow et al. (2010), in healthcare, and Prasanna and Vinodh (2013), for SMEs. In addition, a general structured review of literature on LSS has been carried out by Zhang et al. (2012) and a small number of traditional literature reviews on LSS have appeared recently, e.g. Wang et al. (2012) and Ahmed et al. (2013). It is thus argued here that there is a clear need for further systematic reviews to be carried out in the field of Lean Six Sigma to bridge the gap in previous literature.

This section of the chapter aims to present a systematic review of all the existing papers in leading journals and specialist journals in LSS from 2000 to 2015, to explore the most common themes in the published material in the field of LSS and to identify the gaps in each theme with respect to different industries. The selection of these top journals was determined by using the journal ranking list in the *International Guide to Academic Journal Quality* (ABS, 2011) and from Harzing (2012).

2.5.1 Approach and phases

The approach includes a systematic literature review process, as shown in Table 2.2. These 10 steps are fundamental and need to be followed in a systematic review. They are underlain by three phases, as shown in Figure 2.6. The process and phases in this approach have been adapted from several academic sources, including Okoli and Schabram (2010), Thomas et al. (2004) and Tranfield et al. (2003).

Table 2.2: Research process and definition for each step

Process	Definition
1- Research purpose and objective	The purpose and objectives are clearly identified after a review of the most common gaps that appeared in the literature.
2- Develop research protocol	The protocol includes the study scope, strategy, criteria, quality assessment, and data extraction. This protocol will be followed during the systematic literature review process.
3- Establish relevance criteria	The research criteria help to ensure only the papers most relevant to the research question are included, and unrelated papers are excluded.
4- Search and retrieve the literature	Electronic search for relevant articles in top academic and specialist journals, and manual research in bibliography lists if needed.
5- Selection of studies	Dependent on research criteria
6- Quality assessment for relevant studies	Using appropriate tools to assess articles for quality. Each article should be scored for its quality, depending on the methodology used.
7- Data extraction	Extract the relevant data from each study included in the review.
8- Synthesis of studies (analysis)	Using appropriate techniques, such as quantitative or qualitative analysis, or both to combine the extracted facts.
9- Reporting	Reporting the systematic literature review in detail, as well as the results of the review.
10- Dissemination	Publishing the systematic review in an academic journal to make a contribution to knowledge in the field.

(Source: Okoli and Schabram, 2010; Thomas et al., 2004; Tranfield et al., 2003)

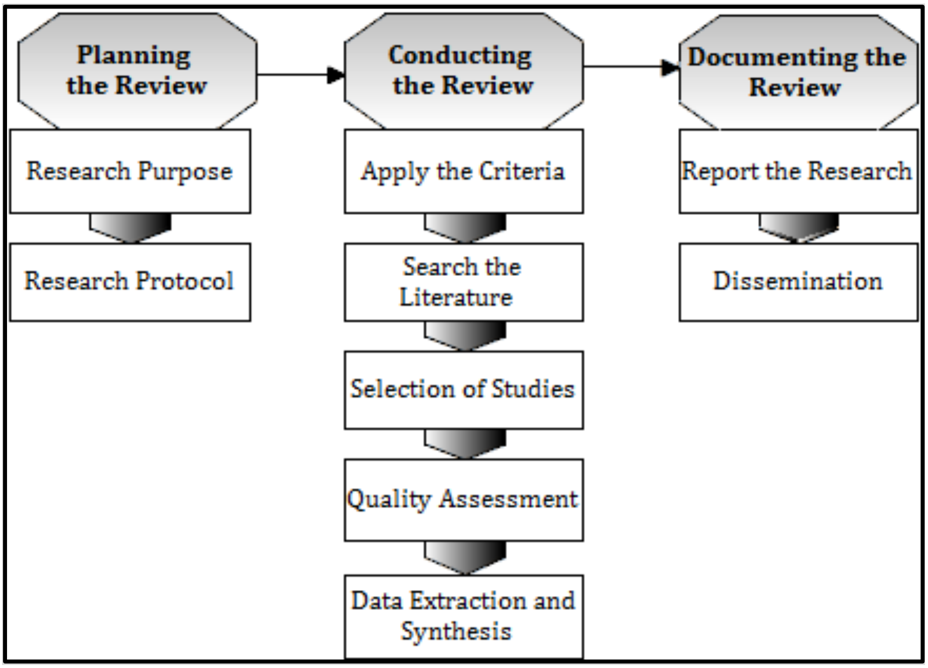


Figure 2.6: Summary of research phases and processes
(Source: Okoli and Schabram, 2010; Thomas et al., 2004; Tranfield et al., 2003)

2.5.2 Criteria

Inclusion and exclusion criteria are stated in order to make it clear to the reader why some articles with which they are familiar have been excluded from the review (Booth et al., 2012). Okoli and Schabram (2010) argue that simplifying research by criteria by firstly reviewing the title, and then the abstract, when needed, helps the researcher to save time and effort. Adopting this approach, the author has gone through papers by title and then abstract, where required, and by this means has included all papers that meet the inclusion criteria, but use of this method means that not all unrelated papers could be excluded (see Table 2.3).

Table 2.3: Research criteria

Inclusion	Exclusion
- Articles published between the years 2000 and 2015	- Any publication before the year 2000
- Articles published in 2-star journals at minimum, according to ABS (2013) and Harzing (2013) in operation management topics	- Low-ranking journals (less than 2 stars)
-Articles published in specialist journals	- Non-relevant journals
- Empirical studies and research papers in different sectors, including public, private, manufacturing, service, higher education	- Papers not related to LSS
- Papers based on quantitative or qualitative analysis, or a mix of both methods	- Papers based on poor analysis or presenting vague results
- Academic Journals and academic databases	- Books, online sites and grey literature (conferences, reports, working papers from research groups, technical reports, etc.)

2.5.3 Material and outcomes

The “journal” search for research literature was carried out through 46 top academic journals (see Tables A.1 and A.2 in Appendix A) and 9 specialist journals in the fields of Six Sigma, Lean and LSS that are published in nine well-known databases: Emerald, American Society for Quality (ASQ), Inderscience, Taylor & Francis, Elsevier, Informs, IEEE Xplore, ProQuest and John Wiley & Sons. Search strings were used as follows: [(lean) and (six sigma) or (lean six sigma) or (continuous improvement) or (process management) or (lean management) or (lean thinking) or (lean manufacturing) and (status) or (current level) or (theme) or (characteristics)] or [(lean and six sigma) or (lean sigma) and (manufacturing) or (service) or (higher education) or (health care) and (case study) not (design for six sigma)]. In addition, the literature search was limited to the English language only. However, some journals were excluded from the review due to the absence of articles related to the research criteria. Nevertheless, key article references were searched (including: Aboelmaged, 2010;

Alsmadi et al., 2012; Antony and Banuelas, 2002; Antony and Desai, 2009; Antony et al., 2005; Chakrabarty and Chuan Tan, 2007; Chakravorty and Shah, 2012; Kumar and Antony, 2008, 2009; Kumar et al., 2006; Nonthaleerak and Hendry, 2008; Salah et al., 2010; Thomas et al., 2014; Timans et al., 2012). These criteria helped the researcher to obtain access to more research keywords, top journals and databases. This search of journals and databases confirmed that there were no research articles related to Lean Six Sigma to be found before 2003. This result is supported by many researchers, including Wang et al. (2012), who have reported that no LSS publications were found before the year 2003.

2.5.4 Results of the systematic literature review

After a long journey and a deep review of the available literature on LSS, a number of key issues have been identified, and these are described in this section of the chapter.

2.5.4.1 Growth of LSS publications

There has been a noticeable increase in the number of LSS publications in academic journals since 2003, which is the year of the first published articles on LSS in the manufacturing sector, one by Smith (2003), and another by William and Willie (2003), which presented the Honeywell experience in implementing LSS. The third article in that year was by Antony et al. (2003), describing the possible synergy of Lean and Six Sigma, although the first known integration of Lean and Six Sigma in that sector was in 1986, in the George Group in the USA (Salah et al., 2010). As shown in Figure 2.7, which shows the growth in publications from 2003 to 2015, 2012 witnessed the highest number of publications, with 18 articles, after a limited number of publications from 2003 to 2011. However, this number dropped to nine articles in the following two years and 10 articles in 2015. This number of articles is still low, but, nevertheless, there is an incremental growth trend.

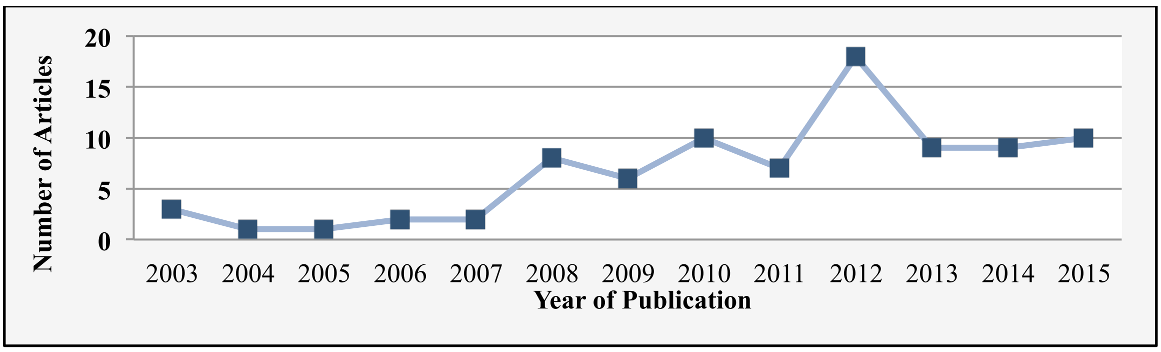


Figure 2.7: Growth of LSS publications from 2003 to 2015

The analysis of the distribution of publications across different sectors, shown in Figure 2.8, shows that the vast majority (30) of the articles were research papers, including literature reviews, presentation of a viewpoint, and developing a framework; this was followed by 26 papers on the manufacturing sector, 10 on the service sector, nine on healthcare, six on SMEs, four on higher education and one on the construction industry. This finding supports that of Lee et al. (2013) who concluded that the majority of LSS publications focus on the improvement of the manufacturing sector.

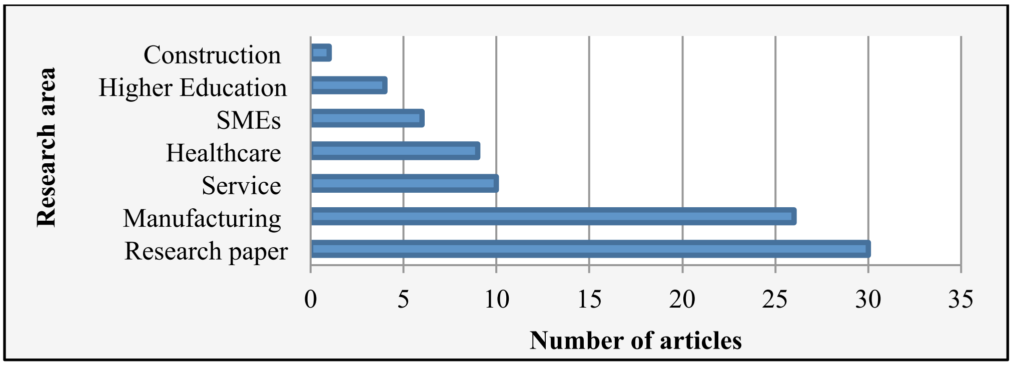


Figure 2.8: Distribution of publications across different sectors

The comparatively low volume of articles indicates that there is a crucial need for more research into LSS implementation across the different sectors, especially as LSS implementation is growing rapidly in popularity in this area, as evidenced by leading corporations citing LSS as a cornerstone philosophy for their businesses. However, this low number of LSS publications is still sufficient to conduct a systematic literature review in the field of LSS, as there is not an agreed minimum number of papers that should be reviewed when conducting a systematic review. It was noticed that in a number of systematic reviews published in academic journals only a small number of papers have been reviewed by the authors. For instance, Medeiros et al. (2011) systematically reviewed only 14 papers which met their research inclusion criteria.

2.5.4.2 Distribution of publications across different countries

Analysing the distribution of publications on LSS across different countries resulted in 19 countries being represented, as shown in Figure 2.9. The USA received the most attention, with 33.70% (29 papers) of the total publications. The UK was in second place, with almost half that number (13 papers) and the Netherlands was in the third place with 12 papers. Other countries such as Canada, Greece, New Zealand and Saudi Arabia, were found to be far behind the USA in the attention they had received in published papers.

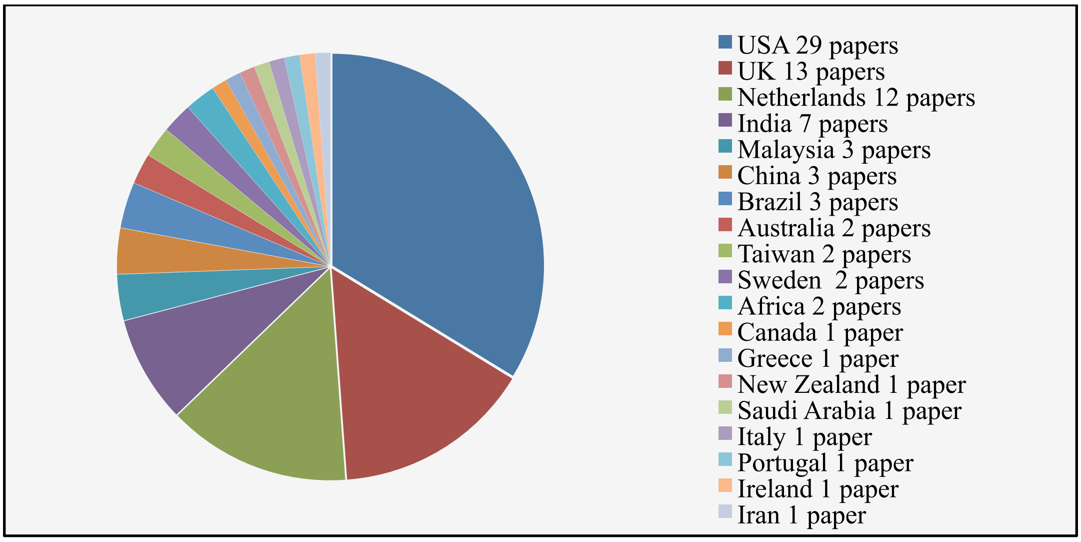


Figure 2.9: Distribution of publications on LSS across different countries

2.5.5 LSS paper themes

This section of the chapter aims to explore the most common themes that appeared in 86 LSS papers in different sectors, including manufacturing and service. The most common themes that emerged in the literature were CSFs, benefits, tools and techniques, motivation factors, limitations, impeding factors and failure factors, as shown in Table 2.4. These themes are presented in detail in this section, as they will guide the researcher to design the empirical study and answer the research questions in the following chapters. The data collected for analysis and the key findings of this section are presented in tabular and graphical form to make them easier to understand.

Table 2.4: LSS papers – themes

Theme	No. of papers
Benefits	46
Motivation factors	46
Critical success factors (CSFs)	28
Impeding factors/challenges	18
Critical failure factors (CFFs)	16
Limitations	12

2.5.5.1 Benefits of successful LSS implementation

Another theme found in the papers concerns the benefits gained from LSS implementation. A review of 86 LSS papers found 44 case studies of organisations in eleven different countries (the USA, the UK, India, the Netherlands, China, Taiwan, Malaysia, Saudi Arabia, Portugal, Ireland, and New Zealand). These are shown in Table A.4 in Appendix A. The table also shows factors outside LSS, as well as other tools and techniques that helped these organisations with successful implementation.

The results show that more than 50 benefits were identified in the 44 case studies. The most frequently stated benefits were: increased profits and financial savings (up to $3bn in some cases) (Corbett, 2011); increased customer satisfaction (in around 50% of the reviewed papers); reduced costs, and significantly reduced cycle time. Kucner (2009) reports that in navy-commissioned nuclear aircraft carriers in the US, lead time was reduced from 180 days to 40 days. A number of cases cited a reduction in inventory and in-process waste, as well as a reduction in the percentage of production defects. In addition, six companies experienced a reduction in machine downtime and machine setup time. Other soft benefits, such as identifying different types of waste, development in employee morale towards creative thinking and reduction in workplace accidents as a result of housekeeping procedures, also appeared in a number of cases. The top 10 benefits cited in the research are:

1- Increased profits and financial savings.
2- Increased customer satisfaction.
3- Reduced cost.
4- Reduced cycle time.
5- Improved key performance metrics.
6- Reduced defects.
7- Reduction in machine breakdown time.
8- Reduced inventory.
9- Improved quality.
10- Increased production capacity.

In addition, no common industry was found in analysing the type of industry represented in these LSS cases. Industry types varied from large industries, such as aircraft manufacturing and proprietary military products, large hospitals and well-known universities, to SMEs and the service sector. Hence, the author argues that this variation illustrates the success of LSS in all types of industry.

It should be noted that, although the author observed a rich seam of publications reporting LSS benefits, no studies were found reporting a failure of LSS implementation. There may be many reasons for this: businesses are presumably not keen to spend time and effort preparing studies for publication that only demonstrate failure, or it may be bias in the selection of articles for publication by the various journals, who only want to report successes. The fact remains that this is a significant omission: publication of detailed analysis of failed implementations or projects would be of great benefit to those businesses contemplating LSS implementation in the future.

Table A.4 in appendix A shows the most common tools and techniques that emerged from the cases. The top 10 common tools are shown in Figure 2.10.

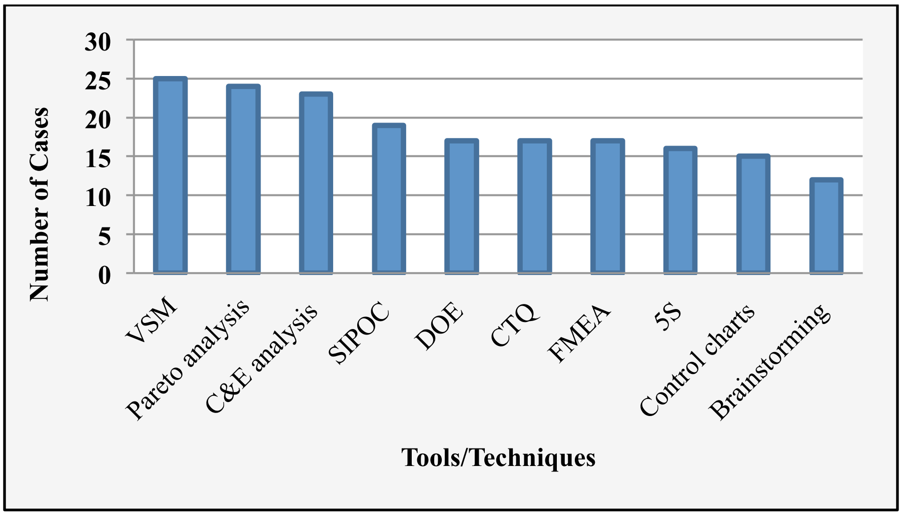


Figure 2.10: Top 10 LSS Tools/Techniques used in the case studies

These tools and techniques were used under the DMAIC method, in almost all cases, as DMAIC is the solid basis for LSS implementation (Chakravorty and Shah, 2012). The reason behind the common use of these tools and techniques in most cases is their simplicity, especially the top three tools, as they are straightforward and do not contain any statistical equations or formulae. Thomas et al. (2009) argue that organisations avoid deploying Six Sigma as a result of the heavy statistical nature and the complexity of these tools and techniques. In addition, management and employees become frightened when these tools are discussed. Hence, most of the organisations, especially in the UK and Europe, would prefer to deploy Lean tools, as they are non-statistical tools.

2.5.5.2 Motivation factors for LSS implementation

Motivating factors are one of the most common themes that appear in the LSS literature. Searching the literature for the factors that motivate organisations to deploy LSS resulted in identifying 19 different factors, as cited in Table 2.5. These factors have been extracted from 46 papers, most of which are case studies.

Table 2.5: Motivation factors for LSS implementation

Motivation factors	References
To reduce the cost of quality (cost of poor quality, production cost, and so on)	(Akkerhuis et al., 2015; Bisgaard and Does, 2009; Chen and Lyu, 2009; Erdmann et al., 2010, 2013; Franchetti, 2014; Harlan et al., 2015; Kemper et al., 2009; Kumar et al., 2006; Niemeijer et al., 2012; Pickrell et al., 2005; Thomas et al., 2009; Wang and Chen, 2012; Wijma et al., 2009)
To improve product and process quality	(Bisgaard and Does, 2009; Chakravorty and Shah, 2012; Chen and Lyu, 2009; Franchetti and Yanik, 2011; Hardeman and Goethals, 2011; Laureani et al., 2010; Pickrell et al., 2005; Richard, 2008; Schoonhoven et al., 2011; Thomas et al., 2008, 2009; Wijma et al., 2009)
To increase customer satisfaction, attraction and loyalty	(Akkerhuis et al., 2015; Anderson and Kovach, 2014; Chen and Lyu, 2009; Fornari and Maszle, 2004; Franchetti and Yanik, 2011; Kumar et al., 2006; Laureani et al., 2010; Richard, 2008; Roth and Franchetti, 2010; Snee, 2010; Vinodh et al., 2012)
To improve process efficiency	(Bhat et al., 2014; Fornari and Maszle, 2004; Franchetti and Barnala, 2013; Hardeman and Goethals, 2011; Lee et al., 2013; Lokkerbol et al., 2012; Panat et al., 2014; Roth and Franchetti, 2010; Schoonhoven et al., 2011; Svensson et al., 2015; Wijma et al., 2009)
To increase the bottom-line	(Akbulut-Bailey et al., 2012; Anderson and Kovach, 2014; Corbett, 2011; Kumar et al., 2006; Lokkerbol et al., 2012; Schoonhoven et al., 2013; Snee, 2010; Thomas et al., 2008; Wijma et al., 2009; William and Willie, 2003)
To change the competitive position in the market or to stay in the competition in the international market	(Akbulut-Bailey et al., 2012; Chakravorty and Shah, 2012; Corbett, 2011; Franchetti and Yanik, 2011; Hilton and Sohal, 2012; Maleyeff et al., 2012; Roth and Franchetti, 2010; Thomas et al., 2008)
To reduce defects in the process	(Bhuiyan et al., 2006; Gupta et al., 2012; Kumar et al., 2006; Richard, 2008; Vinodh et al., 2012; Wang and Chen, 2012; Yi et al., 2012)
To increase production capacity e.g. by reducing machine breakdown time	(Franchetti, 2014; Franchetti and Barnala, 2013; Harlan et al., 2015; Kuiper et al., 2014; Thomas et al., 2009)
To reduce waste	(Niemeijer et al., 2012; Panat et al., 2014; Wang and Chen, 2012)
To increase sales (revenue)	(Franchetti and Yanik, 2011; Schoonhoven et al., 2011; Zwetsloot and Does, 2015)
To reduce customer returns backlog or support labour	(Franchetti and Yanik, 2011; Kumar et al., 2006; Yi et al., 2012)
To improve employees' morale and job satisfaction	(Chakravorty and Shah, 2012; Laureani and Antony, 2010)
To discover causes of variation and waste in the process	(Lee and Wei, 2009; Roth and Franchetti, 2010)
To enhance business sustainability	(Maleyeff et al., 2012; Pickrell et al., 2005)
To reduce inventory	(Kumar et al., 2006; Pickrell et al., 2005)
To change operations to show positive results	(Chakravorty and Shah, 2012; Thomas et al., 2009)
To increase market share	(Akkerhuis et al., 2015; Franchetti, 2014)
To reduce rework	(Anderson and Kovach, 2014)
To implement continuous improvement strategies	(Chakravorty and Shah, 2012)

Figure 2.11 presents the top 10 motivating factors behind the implementation of LSS. In most of the cases, the common reasons for deploying LSS are to reduce cost, improve the quality of products or services, to increase customer satisfaction, attraction and loyalty, and to improve process efficiency.

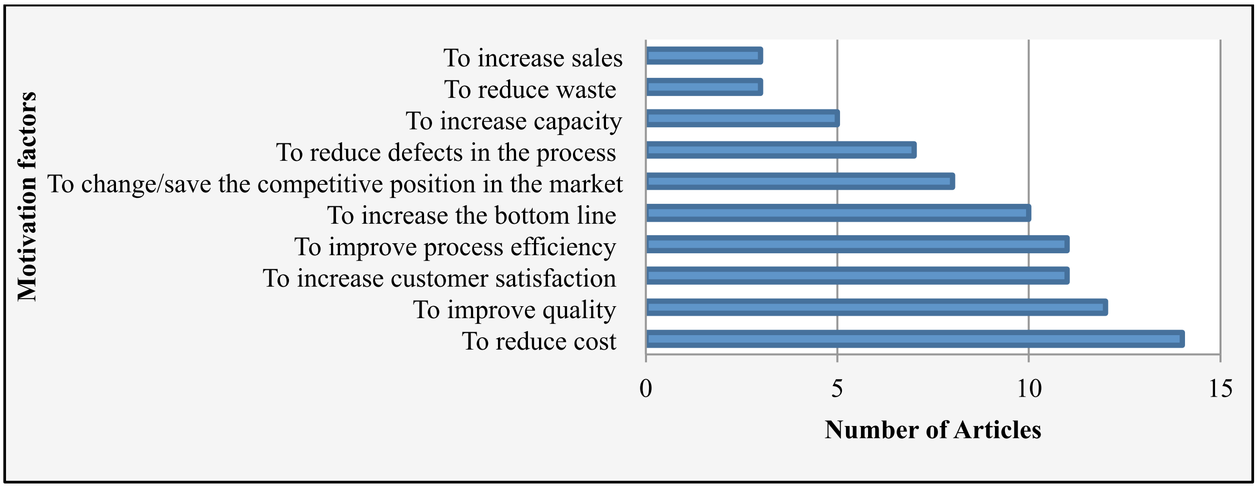


Figure 2.11: Top 10 Motivation factors for LSS implementation

The real benefits gained in the manufacturing and service sectors also motivate other organisations in different sectors, such as higher education, construction, banks, insurance, healthcare and others to implement LSS.

A number of factors appear in only one study: for example, Chakravorty and Shah, (2012) state that implementation of LSS can improve employees' morale and job satisfaction. This view is supported by a single case study, carried out by Vinodh et al. (2012), on rotary switch manufacturing in India. This factor needs to be supported by more research to explore the relation between LSS implementation and the human factor. Thomas et al. (2009) suggest that reducing machine downtime is a big step towards reducing lead time. Hence, organisations save hard cash to the bottom-line by reducing machine downtime. This view is supported by many studies, for instance Vinodh et al.'s (2012) case study on rotary switch manufacturing in India and Kumar et al.'s (2006) case study on automobile accessories manufacturing in India.

In addition, the author observed that most of the organisations were motivated to apply LSS to increase customer satisfaction or to reduce costs and to save hard cash to the bottom-line. However, these organisations may not have been aware of all the LSS possibilities for improvement in the different departments in their organisations. This illustrates the lack of organisational awareness of the benefits of LSS. It is argued here that there is a strong relation between motivation and benefit, as lack of motivation leads to fewer benefits. An organisation's motivation can be increased by the use of other companies' success stories and understanding their motivation factors for deploying LSS, as well as the benefits they gained from LSS.

2.5.5.3 CSFs for LSS implementation

One of the most common themes in papers published on LSS implementation is critical success factors (CSFs). The concept of identifying CSFs for managers was popularised by Rockart (1979) to determine the information that managers need. Rungasamy et al. (2002, p.218) define CSFs as "those factors essential to the success of any program or technique, in the sense that, if objectives associated with the factors are not achieved, the application of the technique will perhaps fail catastrophically". Similarly, Timans et al. (2012, p.340) define CSFs as "those factors that are critical to the success of any organization, in the sense that if the objectives associated with the factors are not achieved, the organization will fail." In terms of LSS, these definitions mean that there are certain factors that should be met during the implementation of LSS; otherwise the implementation will be doomed to fail. Thus, Laureani and Antony (2012) argue that organisations can ensure success if they direct their effort and focus onto the critical success factors. There are 28 different critical success factors that appear in 28 of the papers: most of them were from the manufacturing sector, as cited in Table A.3 in Appendix A.

An analysis of CSFs across countries showed that there are some factors considered to be critical in all the countries under study, as shown in Figure 2.10: these include training and education[2], communication and top management commitment and involvement. In the literature examined, these factors were considered to be the most common critical factors for LSS success in the USA, the Netherlands, the UK, Malaysia, Australia and India.

[2] Training is "improving performance on the present job" while Education is "preparing individuals for future but identifiable jobs within the organization" (Nadler, 1970, p.47).

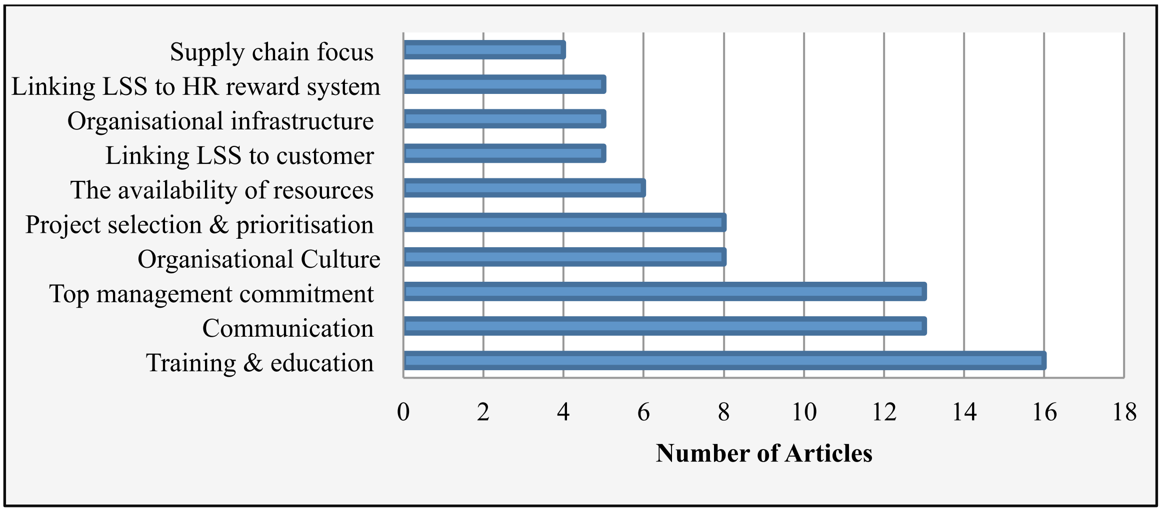


Figure 2.12: Top 10 Critical Success Factors for LSS

Training and education is the most cited factor in the literature, in a total number of 18 of the reviewed papers. This is followed by communication and top management commitment and involvement, which are cited in 16 papers. Other factors such as organisational culture and project selection and prioritisation are considered to be less important, in some cases.

However, critical success factors vary from study to study and from company to company, as well as between different countries. Some CSFs cited as important in previous studies are found to be less important in other studies: for example, Jeyaraman et al. (2012), in their study on the Malaysian electronic manufacturing service (EMS) industry, and Timans et al. (2012), in their study on Dutch SME manufacturing, found that project selection and prioritisation is not even in the top five factors for the successful implementation of LSS. On the other hand, this factor was cited as one of the most important CSFs by Snee (2010) and Snee and Hoerl (2007). Thus, the researcher argues that it is important to shed light on the CSFs across countries and explore the top five CSFs in each country that appears in the literature as shown in Table 2.5.

Table 2.6: Top five CSFs across countries

CSF	USA	Netherlands	UK	India	Malaysia	Australia
Training and education	X	X	X	X	X	X
Communication	X	X	X		X	X
Top management commitment and involvement	X	X	X	X	X	X
Project selection and prioritisation	X	X			X	
Organisational culture	X	X		X		
Finding and understanding the problem correctly in the first place				X		
Employee engagement and their active				X		

involvement throughout the LSS deployment			
Availability of resources	X	X	X
Effective and efficient performance measurement and management system			X
Organisational infrastructure	X		

The above analysis of the CSFs in different countries shows that communication comes at the top of the list in the USA, the UK, Malaysia and Australia, while this factor is less important in India. This variation could be as a result of the lack of studies that have been undertaken to explore the CSFs in India, indicating that more research is needed to address this gap in the literature. Moreover, one of the most important factors for LSS success in the UK is the availability of resources. The analysis of the results showed that this factor is a more common issue in UK SMEs than in large organisations, as SMEs always suffer from a lack of resources, especially financial resources. Future research is very important in this area. Why are UK SMEs suffering from lack of resources? And, what is the radical solution for this problem?

In some studies, CSFs emerged that had never been encountered before. These included: the development of a project leader's soft skills, which emerged in Timans et al.'s (2012) case studies on SMEs in the Netherlands; patience to see the results and developing an employee mindset of using LSS principles in daily activities (Akbulut-Bailey et al., 2012); and sustainability of results (Snee, 2010). These variations in CSFs could be a result of the variations in cultures between the nature of the organisations and between countries. In addition, some particular CSFs emerged in the USA and the Netherlands. It is important that these factors are adopted by other countries, particularly sustainability models for sustaining the results. This concept emerged from Snee (2010), who argues that improvement should be sustainable. However, sustainability needs a framework, training, communication, rewards, and other factors. The present author particularly notices the absence of a framework for sustainability and the lack of research in this area.

2.5.5.4 Impeding factors/challenges for LSS implementation

Organisations and practitioners applying LSS in different sectors, face a number of complex impeding factors. These factors or challenges, as cited in 18 papers, are presented in Table 2.7.

Table 2.7: Impeding factors /challenges for LSS implementation

Factors	Description	References
Unavailability of resources	Richard (2008) points out that implementing LSS projects requires using resources. These resources are not always available in the organisation; hence, this is undoubtedly a major challenge in LSS implementation.	(Richard, 2008; Thomas et al., 2008, 2014; Timans et al., 2012)
Time-consuming	One of the challenges that always faces executives in companies is the time it takes for LSS project implementation (Richard, 2008).	(Pepper and Spedding, 2010; Richard, 2008; Smith, 2003)
Internal resistance	Results of Timans et al.'s 2012 survey in SMEs showed that 54% of the respondents mentioned internal resistance as a barrier to LSS implementation.	(Antony et al., 2003; Hess and Benjamin, 2015; Timans et al., 2012)
Lack of training or coaching	Thomas et al. (2008) concluded that many companies have failed in LSS implementation as a result of the lack of training and knowledge of LSS tools and techniques.	(Breyfogle, 2008; Thomas et al., 2008; Timans et al., 2012)
Unmanaged expectations	In many cases, expectations about results vary between senior managers and practitioners. This should be addressed from the very early stages of LSS implementation (Thomas et al., 2008). In some cases, organisations cannot achieve the expected benefits to the bottom-line (Richard, 2008) and this leads the whole project to fail. Hence, the organisation wastes money, time and effort with no specific improvement.	(Richard, 2008; Thomas et al., 2008; Timans et al., 2012)
Lack of visionary leadership	In Timans et al.'s (2012) SME survey results, 39% of the respondents mentioned lack of leadership as a barrier to LSS implementation.	(Antony, 2015; Antony et al., 2003; Timans et al., 2012)
Employee attitude towards a new business strategy	In many cases, employees think that new business strategies could put them at risk of losing their jobs if their performance is seen to be below the required level	(Antony et al., 2003; Kumar et al., 2006; Vinodh et al., 2012)
Lack of awareness about LSS benefits in business	This is one of the top challenges facing businesses, but can be tackled through training and education, as well as by learning lessons from previous success stories of other organisations (Snee, 2010).	(Kumar et al., 2006; Snee, 2010; Thomas et al., 2008)
Lack of tangible results	All the reviewed case studies showed many positive and tangible results, such as savings in the bottom-line, quality improvement and so on. However, Timans et al. (2012) argue that in some cases, the company does not get any	(Douglas et al., 2015; Timans et al., 2012)

	positive results from the deployment of LSS and this impedes the company from completing LSS projects.	
Competing projects	This relates to the selection of projects, which may be competing for implementation of resources. Managers should use appropriate criteria to select the most beneficial projects, as well as project selection tools and techniques such as brainstorming, Critical to Quality (CTQ), focus group, and Kano analysis.	(Douglas et al., 2015; Timans et al., 2012)
Convincing top management	Top management often believe that investment in quality improvement programmes is merely wasting money and increasing production costs (Kumar et al., 2006).	(Kumar et al., 2006; Vinodh et al., 2012)
Difficulties in teaching statistical methods to some of the team members	Many LSS team members are not familiar with statistics (Chakravorty and Shah, 2012). To solve this problem, authors suggest using LSS learning games to make complex tools and techniques easy to understand.	(Chakravorty and Shah, 2012; Thomas et al., 2009)
Lack of skills required for successful deployment	Lack of skills such as managerial, technical, statistical can be a significant barrier to LSS implementation. Without the availability of skilled members, driving a new culture into the organisation could be impossible (Thomas et al., 2008).	(Franchetti and Yanik, 2011; Thomas et al., 2008)
Poor organisational structure	Thomas et al. (2008) believe that problems in organisational structure, such as financial and technical problems can limit the success of implementation of LSS.	(Thomas et al., 2008)
Poor employee relationships	This can affect LSS implementation. It is important for LSS employees to have good relations with each other to enhance the probability of project success and make for an effective working environment.	(Timans et al., 2012)
National regulations	Both lack of regulation and overregulation put pressure on companies and prevent them being able to operate effectively within the global market (Maleyeff et al., 2012).	(Maleyeff et al., 2012)
Poor selection of projects	This can cause wasting of time, effort and resources. It also causes scepticism among many people and might kill the initiative eventually.	(Timans et al., 2012)
Changing business focus	In Timans et al.'s (2012) SME survey results, 43% of the respondents mentioned changing business focus as a barrier to LSS implementation.	(Timans et al., 2012)

The implementation of any CI programme must overcome impediments, and it is valid to discuss some of the impeding factors that faced organisations while they were implementing their LSS programmes. Table 2.7 depicts the impeding factors to LSS implementation reported in the literature. The top five impeding factors reported are:

1- Unavailability of resources.
2- Time-consuming.
3- Internal resistance.
4- Lack of training or coaching.
5- Unmanaged expectations.

Other factors have emerged from these studies, for example, convincing the top management about the benefits of LSS in business. This factor is due to a belief by top managers that investment in quality improvement programmes is no more than wasting money and increasing production cost (Kumar et al., 2006). The author argues that from the results of the reviewed case studies, this view cannot be true. It can be seen that organisations gained massive savings to their bottom-line as a result of investment in quality improvement programmes.

A number of factors emerged in the studies by Timans et al. (2012), Thomas et al. (2008), Maleyeff et al. (2012), Chakravorty and Shah (2012) and Richard (2008). Lack of tangible results is one of the impeding factors reported by Timans et al. (2012). The author argues that this factor cannot be a true impediment, because around 50 tangible results have been extracted from reviewed case studies across different sectors. For instance, 50% of the reviewed papers reported significant increases in savings and the bottom-line, of up to $3bn in some cases, and significantly decreased cycle time, by an average of 25% to 50% (as reported by Kucner, 2009, in a navy-commissioned nuclear aircraft carrier project in the USA, lead time was reduced from 180 days to 40 days). A number of cases cited reductions in inventory and waste in processes, as well as reduction in the percentage of production defects. It can, therefore, be argued that it is possibly a lack of visible results rather than a lack of tangible results that is at issue here.

Many authors such as Richard (2008) and Pepper and Spedding (2010) have argued that the implementation of LSS projects in an organisation often takes too long and this is one of the challenges facing executives in organisations. Master Black Belts (MBBs) have been found to spend around six months or more on each LSS project and LSS projects usually take months to be completed (Smith, 2003). However, Snee (2010) argues that the implementation of LSS projects should not take more than three to six months, and this is one of the characteristics that differentiate LSS from other improvement initiatives. The author observed a clear variation in authors' views towards the time taken for LSS project execution. This variation could be as a result of factors such as differences in culture, LSS awareness and level of training, as all these factors affect the time required for LSS implementation. Future research, such as an empirical study, is needed to address this gap in the literature.

2.5.5.5 Lean Six Sigma critical failure factors

Garg and Garg (2013, p.498) and Ganesh and Mehta (2010, p.46) define CFFs in terms of Enterprise Resource Planning (ERP) as "the key aspects (areas) where things must go wrong in order for the ERP implementation process to achieve a high level of failure". They also define failure as "an implementation that does not achieve a sufficient return on investment (ROI) identified in the project approval definition". Moreover, according to Al-Mashari's (2001) ERP study, "strategy development is critical to ERP implementation, as its absence has resulted in poor outcomes" A number of academic papers have investigated CFFs, such as the study undertaken by Yeo (2002) on CFFs in an information system (IS) project. Yeo, (2002) studied the interaction between certain factors, such as organisational, financial, technical, human, and political factors, which were then identified as CFFs for an IS project. However, this study did not define the term CFFs but only defined some situations when the project was defined as a failure. Another study carried out by Belassi and Tukel (1996) in project management CSFs/CFFs only listed some factors that lead projects to succeed or fail, without any definitions for CFFs.

2.5.5.5.1 Lean Six Sigma failures in the literature

There seems to be insufficient research investigation on the critical failure factors of LSS. Hence, the author argues that this part of the thesis will be valuable in term of identifying the CFFs of LSS. Through systematically reviewing the literature, this section of the chapter explores the most common factors reported in academic journals as leading to Lean Six Sigma failure in different industries.

A number of authors have argued that, although some companies have successfully deployed CI initiatives such as Lean and Six Sigma, a significant number of companies have failed to gain any benefits from their deployment and other companies have failed to achieve the expected results (Kumar et al., 2008a; Kumar et al., 2008b; Martinez-Jurado and Moyano-Fuentes, 2012).

According to Ringen and Holtskog (2011), of every three CI initiative projects in general, two fail to attain the expected results. Moreover, Pedersen and Huniche (2011) reported that up to 70% of the companies implementing Lean had failed. In 2006, research conducted in UK organisations implementing Lean showed that fewer than 10% of the organisations had implemented it successfully (Bhasin and Burcher, 2006).

Several authors, including Chakravorty (2009), Kumar et al. (2007) and Kumar et al. (2008b) have reported a survey of aerospace companies carried out in 2005. The results of this survey showed that respondents' satisfaction with Six Sigma results was lower than 50%, while only 20% were satisfied and 30% were dissatisfied. Feng and Manuel (2007) in their survey of health-care companies found that 54% of the surviving companies did not anticipate implementing the Six Sigma strategy. A review of 47 studies in health care undertaken by Glasgow et al. (2010) concluded that 62% of Six Sigma and Lean initiatives failed as a result of a lack of stakeholder acceptance.

These failures and dissatisfaction with the results are not because of a shortage of improvement programmes. Most of the companies failed to pay attention to the critical success factors during implementation, such as top management commitment and involvement, communication with the shop floor workers, selection of projects, training, and so on (Albliwi et al., 2014). Hence, a significant number of CI projects have failed (Chakravorty, 2009; Laureani and Antony, 2012; Snee, 2010). Moreover, the success or failure of LSS implementation depends on how and where it is applied (Duarte et al., 2012).

The search of the reviewed papers illustrated that there is a clear limitation in these publications in respect to studies regarding the factors that lead to LSS failure. Therefore, this research aims to narrow the gap in the literature by exploring the most common CFFs of LSS. The systematic literature further showed that there are 16 papers on LSS failure and that the first paper to discuss LSS failure was published in 2009 by Thomas et al. Moreover, the search of databases for Lean failure factors resulted in 16 papers, while Six Sigma failure factors appeared in 30 papers.

Reviewing the papers resulted in 34 factors that lead to Lean and Six Sigma deployment failures (see Table A.5 in the Appendix A). Some of these factors were cited by a significant number of authors, whereas other factors were cited by only one author. The top 10 CFFs are shown in Figure 2.13

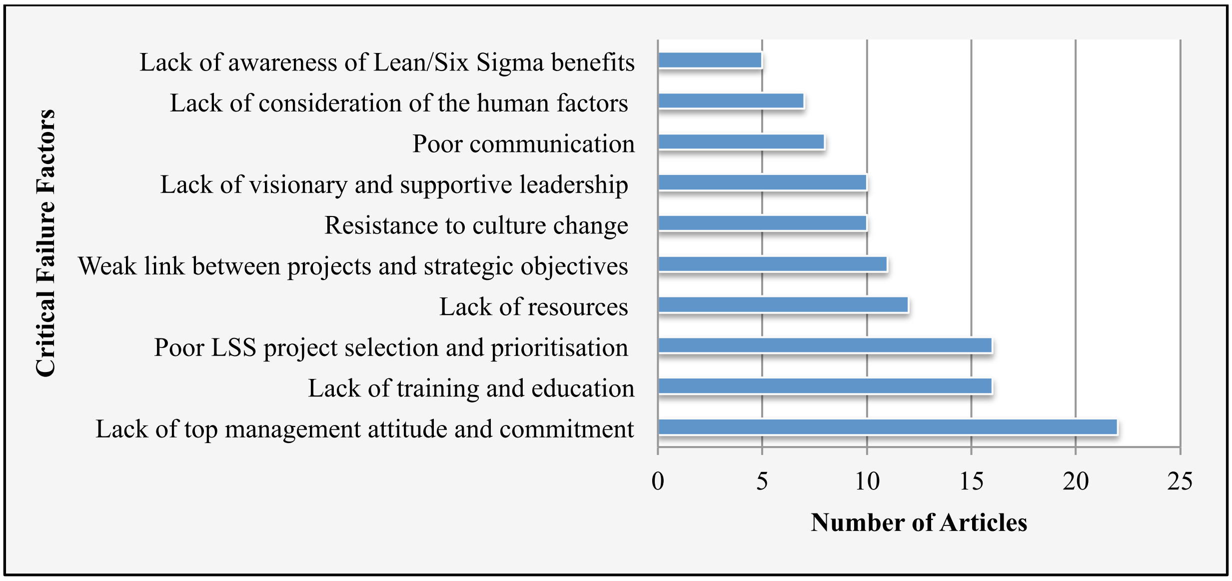


Figure 2.13: Top 10 Critical Failure Factors for LSS

The five most common failure factors will be discussed here:

1- Lack of top management attitude, commitment and involvement has been identified as the most critical failure factor of LSS in this review, as it appeared in 22 of the papers found. This factor has been found to be a critical failure factor across all industries in different countries and different organisational sizes. Many authors, including Ho et al. (2008), Kwak and Anbari (2006) and Snee (2010), have asserted that without top management commitment and support, LSS projects easily fail, and that the role of top management is to ensure that all the required resources are available and that no obstacles occur during the project deployment (Martinez-Jurado and Moyano-Fuentes, 2012; Snee, 2010).

2- Lack of training and education has been cited as the second top factor for LSS failure. Many organisations see training as a waste of money and too costly. However, training should be viewed as a critical factor for the successful implementation of LSS and a procedure to reduce the LSS implementation time (Laureani and Antony, 2012; Snee, 2010), which can make savings for the company and reduce the labour cost (Bhasin, 2012a; Chakrabarty and Chuan, 2009).

3- Poor LSS project selection and prioritisation: both Su and Chou (2008) and Duarte et al. (2012) believe that selecting the wrong project can lead the entire LSS effort to fail.

4- Lack of technical, human and financial resources is one of the major problems faced by most organisations in different countries (Aboelmaged, 2011; Pinto et al., 2008) and different sectors (Antony and Desai, 2009).
5- A weak link between the CI projects and the strategic objectives of the organisation was the fifth most cited failure factor in this study. Antony et al. (2012) argue that it is important to select projects that align with the organisation's strategic goals.

Snee (2010) concludes that improvement programmes fail due to poor deployment. However, taking LSS's eight key characteristics into account is very important for LSS success. These characteristics are "1- creates bottom-line results; 2- active senior management leadership; 3- uses a disciplined approach (DMAIC); 4- rapid project completion (three–six months); 5- clear definition of success; 6- infrastructure created (MBB, BB, GB); 7- focuses on customers and processes; and 8- sound statistical approach" (Snee, 2010).

As mentioned above, it should be borne in mind that there are relatively fewer publications on LSS failures compared to those on its benefits.

2.5.5.6 Limitations of LSS

Many authors have argued that there are a significant number of limitations in LSS methodology. Nine fundamental limitations were addressed in 12 papers, as cited in Table 2.8. These limitations could be a rich area for future research.

Table 2.8: Limitations of LSS

Limitations	Description	Reference
The absence of clear guidelines for LSS in early stages of implementation	Kumar et al. (2006) argue that practitioners need clear guidelines for the direction of the early stages, such as which strategy should come first, Lean, Six Sigma or LSS, and which tools should be used first	(Kumar et al., 2006; Pepper and Spedding, 2010; Thomas et al., 2008; Vinodh et al., 2011)
Lack of understanding of the usage of LSS tools and techniques	Kumar et al. (2006) observed that there was no clear understanding of the usage of LSS tools and techniques in organisations	(Kumar et al., 2006; Pepper and Spedding, 2010; Thomas et al., 2008)
The lack of LSS standardisation curricula	Standard LSS curricula are needed in order to leverage learning in organisations (Salah et al., 2010)	(Breyfogle, 2008; Hilton and Sohal, 2012; Salah et al., 2010)
Lack of a maturity model to measure LSS implementation level	There is a significant need for a measurement system for LSS performance, as most organisations' failure is due to the lack of a Lean/Six Sigma maturity model.	(Albliwi et al., 2014; Chakravorty and Shah, 2012)

No globally accepted standards for certification	Some companies have adapted the LSS certification system for themselves. This causes confusion and lack of trust in the industry	(Breyfogle, 2008; Laureani and Antony, 2012)
Lack of a roadmap to be followed – which strategy first?	This limitation can be resolved by adapting the roadmaps available in literature, depending on specific organisational needs (Snee, 2010).	(Kumar et al., 2006; Snee, 2010)
The limited number of practical applications of LSS integrated framework	More case studies are needed to examine the integrated framework of LSS in different sectors.	(Chen and Lyu, 2009; Vinodh et al., 2012)
The absence of a sustainability framework for LSS	It is important to put in place a plan for sustaining the results before the start of the project implementation phase. This is also a serious limitation. How can an LSS initiative be sustainable?	(Snee, 2010)
Lack of innovation in LSS projects	This limitation is as a result of the implementation of only simple tools for improvement, such as 5S, waste removal, etc. (Thomas et al., 2008)	(Thomas et al., 2008)

This study has also cited limitations in LSS implementation as one of the most common themes, as shown in Table 2.7. The highly cited limitations in the literature are:

1- The absence of clear guidelines for LSS in early stages of implementation.
2- Lack of understanding of the usage of LSS tools and techniques.
3- The lack of LSS standardisation curricula.
4- Lack of a maturity model to measure LSS implementation level.
5- No globally accepted standards for certification.
6- Lack of a roadmap to be followed – which strategy first?

Regarding the absence of a roadmap for LSS implementation, especially in the early stages, Kumar et al. (2006) argue that practitioners need a clear guide for the direction of the early stages: which strategy should come first, Lean, Six Sigma or LSS, and what tools in the toolbox should be used first? Furthermore, Kumar et al. (2006) observed that there was no clear understanding of the usage of LSS tools and techniques in organisations under study. Hilton and Sohal (2012), Breyfogle (2008) and Salah et al. (2010) all recommend that more standardised and more robust LSS curricula are needed in order to leverage learning in organisations. Hence, developing curricula for LSS has emerged in this review as an area for future research.

2.6 Introduction to maturity models

Determining the level of process maturity is critical for business stability, improvement and sustainability of any organisation. Process is defined by Bergman and Klefsjo, (2010, p. 456) as “a network of activities that are repeated in time, whose objective is to create value to external or internal customers”.

The origins of maturity models lie in the software industry from the 1970s onwards, and they have evolved to become an important tool for improvement in organisations aiming to assess process capability (García-Mireles et al., 2012; van Looy et al., 2013). The value of a maturity model is that organisations can capture their current maturity situation easily, without any external help from consultants, and draw a map for future development of their processes (Cronemyr and Danielsson, 2013).

Thus, the second purpose of this chapter is to review, compare and contrast the existing maturity models in areas of quality/operations management, including Bessant’s continuous improvement capability model, the Capability Maturity Model (CMM) and the Capability Maturity Model Integration (CMMI), which is the most common model mentioned in the literature. This review is a critical step in the development of a practical Lean Six Sigma maturity model adapted from the current maturity models for process excellence and from existing Lean/Six Sigma models.

2.6.1 Definitions of a maturity model

A review of the available literature shows that there is a lack of consensus on the definition of a maturity model, and most of the definitions have only described the capability levels, behaviours and the objectives of the model. However, Pullen, (2007, p.1318) has defined a maturity model as “a structured collection of elements that describes the characteristics of effective processes at different stages of development. It also suggests points of demarcation between stages and methods of transitioning from one stage to another”. A maturity model is a tool to help organisations assess the strengths and weaknesses of their business processes. It provides a roadmap for improvement, and evaluates the organisation by comparing the quality standards and best practices of maturity of the organisation to those of other organisations (Pigosso et al., 2013).

2.6.2 The most common maturity models and comparative study of maturity models

This section will discuss the strengths and limitations of some existing models, as well as highlighting their pros and cons. The scope of the chapter also includes comparing and contrasting various maturity models identified in the literature review. The findings are shown in Tables 2.9 and 2.10.

2.6.2.1 Crosby's Quality Management Maturity Grid (QMMG)

This model was developed by Philip Crosby in 1979, and was one of the first maturity models for assessment of quality maturity. Crosby's model contains five stages of maturity and six categories of measurement that help the user to identify their own situation with regard to maturity (Crosby, 1979). This model recognises the importance of human factors such as leadership, attitude and collaborative work (Crosby, 1979).

2.6.2.2 Bessant's continuous improvement capability model

This model was created by John Bessant in 1997 and has five different levels of maturity plus six continuous improvement abilities. Each ability contains a group of behaviours (a total of 32 behaviours) which help organisations to improve their CI capability. The basic idea is to provide a model for assessing the general maturity level and in particular to specify the kind of behaviours for further development (Bessant and Caffyn, 1997). Bessant's model helps organisations to understand where they stand in relation to other organisations (benchmarking). It is also useful in terms of explaining to the organisation how to improve CI ability and embed it into the organisation until CI becomes a way of life for enhancing business performance. The model is very simple and it provides a basic roadmap for development of CI ability (Bessant et al., 2001; Bessant and Caffyn, 1997).

2.6.2.3 Capability Maturity Model (CMM)

This model was developed in 1987 by the Software Engineering Institute (SEI) at Carnegie Mellon University and was sponsored by the US Department of Defense (DOD) (SEI, 2000). It was developed to meet the needs and characteristics of governmental organisations (Hoggerl and Sehorz, 2006).

CMM can be defined as "a reference model of mature practices in a specified discipline, used to improve and appraise a group's capability to perform that discipline" (SEI, 2005, p.13).

According to SEI, CMM is based on the components and concepts of Philip Crosby's maturity model (1979), but the model was modified in 1991 using previous maturity models created by Deming (1986), Juran and Godfrey (1988), and Humphrey (1989). CMM contains five levels of maturity and serves as a guide for an organisation to manage its process for improvement. This model relies on the fact that an organisation can achieve a target maturity level only after the implementation of several phased steps. A model is a simplified representation of the world, and Capability Maturity Models contain the essential components of effective processes for one or more disciplines.

Although this model was originally developed for the software industry, it is also applicable to other organisations in different business sectors, as it covers areas such as risk management, project management, managing and developing the workforce (SEI, 2005).

2.6.2.4 Capability maturity model integration (CMMI)

This model was developed in 2000. It is not a completely new model; rather it shares some similarities in structure and content with CMM and ISO 9000 (SEI, 2000). It can be defined as CMM with some changes in the names of maturity levels (García-Mireles et al., 2012). This model has integrated different CMMs (the previous system) that provide end-user organisations with a framework to address issues related to project management and process in developing products and services (Kishore et al., 2012). This model comprises five maturity levels with 25 process areas; each process area has a set of specific goals and practices for achieving the goals.

CMMI serves as a guiding framework for the development of process, as process is always seen as a major factor in delivering high quality products in the software industry. CMMI has many variants, such as the CMMI for Services (CMMI-SVC), which aims to guide the development, and improvement of organisations to become mature in service practices, and the CMMI for development (CMMI-DEV) (SEI, 2000).

2.6.2.5 ***OMG's Business Process Maturity Model (BPMM)***

BPMM was developed in 2002 by the technology standards organisation, Object Management Group, Inc. (OMG) with the belief that the model will lead to higher levels of business success through the level of process maturity (Raschke and Ingraham, 2010). According to OMG, (2008, p.vii), "The BPMM can be used as a process model by itself or it can be used as a framework for improvement efforts based on other models". This model is similar to the previous maturity models presented above, as it is based on CMM and consists of five levels of maturity and 30 process areas. It is documented comprehensively within 496 pages, while other BPMMs, such as BPMM-Lee, and PEMM, are merely presented in journal articles or book chapters (Röglinger et al., 2012). This model has two key strengths: first, the support given to organisational learning, e.g. learning from mistakes, and second, innovative improvements and problem prevention measures are in place (Röglinger et al., 2012) (see Table 2.9).

Table 2.9: Evaluation criteria for Maturity Models

Criteria	Crosby's Grid	Bessant's Model	CMM	CMMI	OMG
Target	Quality Management	Continuous Improvement	Software Industry	Different Industries	Business Process
User-friendliness	Yes	Yes	No	No	No
Need training for users	No	No	Yes	Yes	Yes
Prior knowledge and experience	Yes	Yes	Yes	Yes	Yes
Clarity of determining the current level of maturity	Yes	Yes	Yes	Yes	Yes
Empirical evidence	No	Yes	Yes	Yes	No
Theoretically based	No	No	No	No	No
Researcher experience based	Yes	Yes	No	No	No
Quality standards/previous models based	No	No	Yes	Yes	Yes
Complexity	No	No	Yes	Yes	Yes
Performance based scoring system	No	No	No	No	No
Accuracy	No	No	Yes	Yes	NA
Availability of criteria to determine the current stage of maturity, when the stage is completed and when to move to the next stage	No	No	No	No	Yes
Validity/reliability/generalisation	No	No	No	Yes	NA

2.6.3 A critique of current maturity models

Although a number of maturity models have appeared in the literature since 1979, there are major voids in terms of missing significant components in each model (see Table 2.10). Moreover, the most common aim for many researchers was to develop maturity models based on practice. Despite the wide popularity of maturity models, they have always been vulnerable to criticism. One criticism is that maturity models are "step-by-step recipes" lacking empirical foundation and reality (Röglinger et al., 2012, p.330). Hence, there is dearth of theoretical reflective publications on such structures (García-Mireles et al., 2012; Wendler, 2012). Instead of focusing on the factors that influence the evolution and drive for improvement, most maturity models rely on levels leading towards a predefined "end state" (Röglinger et al., 2012). There is thus a requirement for criteria that will help users determine the current stage of maturity and acknowledge the methodical progression to the next stage (Cronemyr and Danielsson, 2013). Further issues arise from the multitude of similar maturity models, unsatisfactory documentation, unthinking adoption of the Capability Maturity Model

(CMM) blueprint, and lack of an economic foundation. The major criticism relating to most of the models is that they provide limited guidance on specific steps that should be taken in order to improve maturity levels (Röglinger et al., 2012).

Table 2.10: Summary of Maturity Models

The Model	Year of Development	Purpose	Limitations
Crosby's Grid	1979	- To show where the company is in the quality management spectrum	- Lack of theoretical base - Based on the researcher's practical experience
Bessant's Model	1997	- To assess the maturity level by using the framework and improve what the organisation is doing currently -To determine the behaviours that need to be developed	- The application of this model has not been tested in the public sector or large organisations yet -Some important components and critical success factors are missing
CMM	Late 1987	-To measure practices in a certain discipline -To guide the effort of process improvement in the software industry	- Lack of theoretical base - The way of measuring maturity is very confusing, has different structures, terms, formats, etc. - Needs a team to assess the process by conducting a full-scale audit which is costly, in terms of time and effort - More applicable to large software organisations than any other organisations - Completing the CMM journey does not guarantee project success - Ignores cultural factors and people's capabilities
CMMI	2000	- To develop an integrated framework that includes current and future models which solves the problem of using many CMMs and overlapping - To address project management and process issues in developing products and services	- It suits large and bureaucratic organisations - Exclusive focus on the process - Specific training and experience are essential - Much more applicable to large software organisations than any other organisations - Misses consideration of human factors, cultural factors and organisational factors - Successful use of the model depends on the lead-assessor - Requires a solid theoretical base to be recognised as a trustworthy model
OMG	2002	-To improve business process related to products and services in an organisation -To work as a road map that managers can use for benchmarking and monitoring business process	- The role of IT support is missing in the model -There is a lack of studies that have tested the validity and accuracy of this model. Hence, more studies are needed to test these two points.

Interestingly, even popular maturity models like Crosby's Quality Management Maturity Grid (QMMG) have been subject to criticism by other scholars on the grounds that it is not entirely applicable to business process improvement and it is based only on the author's practical experience. Wendler (2012) argues that QMMG is not described as a lifecycle. Rather, it describes the potential of a higher maturity level, and leaves it to the discretion of the user to decide whether to proceed to the next stage. In addition, a limited number of available maturity models have QMMG as their foundation. It seems to be unknown to many researchers and developers of maturity models.

The model developed by John Bessant for Continuous Improvement (CI) maturity has also faced criticism from other researchers. Fryer et al. (2013) published a paper to revise Bessant's model, arguing that important components and critical success factors, such as communication, had not been covered in the model. In addition, although this model was developed from empirical research in both the private and public sectors, the model has not been tested either in the public sector or large organisations. To date, the model has only been used by SMEs (Small and Medium Sized Enterprises) in the manufacturing sector.

CMM has also been criticised by a number of scholars. Paulk et al. (1993) argue that the model necessitates a team to assess the process by conducting a full-scale audit, which is costly of time and effort. This model is also very confusing for the user in terms of measuring maturity, as it has different structures, terms, and formats. Moreover, there are different CMM formats available that overlap and are contradictory (Hoggerl and Sehorz, 2006).

CMMI is always criticised for its specific focus on the process and neglect of the very important factors of people, culture and organisation, which are critical to project success. It is also criticised by many practitioners, as it requires a specific type of training and experience (Hoggerl and Sehorz, 2006). Moreover, this model focuses on large bureaucratic organisations, although it can still be deployed in small organisations. It is also criticised for the major role the lead assessor plays in the successful deployment of the model – in reality, there should be no difference between the lead assessor and the other members of the team in the successful determination of maturity (Hoggerl and Sehorz, 2006).

There are multiple CMMI models available, generated from the CMMI Framework. Consequently, the user needs to be well-prepared, choosing the best CMMI model commensurate with the process improvement needs of the organisation (SEI, 2000). In addition, both CMM and CMMI were developed to serve large governmental software organisations, therefore their application in other organisations is not as successful.

Interestingly, however, the review of the available models and literature shows that CMMI is obviously the most commonly used model, and the only standard for the majority of the current maturity models, and it is also regarded by academics as the best one (Wendler, 2012).

The last model reviewed in this section is OMG-BPMM. The literature review found that this model is rarely addressed in research, particularly in comparison to CMM and CMMI. This model was criticised by Röglinger et al. (2012) in that it did not cover the important role of IT support. Although this model claims that is applicable across many organisations, industries and locations (Röglinger et al., 2012), these authors call for further research in understanding the accuracy and validity of the model.

In general, most of the available maturity models have been developed using quality standards such as ISO, IEC 15504, CMMI-DEV, Malcolm Baldrige National Quality Award (MBQNA) (Xiaofen, 2013). Other models are based on the adaptation or improvement of previous maturity models such as CMMI, CMM, Bessant's CI model, and a very small number of models are based on Crosby's Maturity Grid. It was also observed in this review that a limited number of maturity models used scientific guidelines as a foundation for their development. Thus, the majority of the available models were developed on the practical experience of the researchers. Hence the theoretical basis is missing in most of the models. The researcher also observed that the validity and generalisation of the models is limited in scope. Therefore, there is a research gap around developing a maturity model that is based on theory for subsequent testing in the real world. In fact, maturity models have always been criticised for lack of consideration for results/performance. That means it is possible to move to the next stage of maturity without any improvement in the business process (OMG, 2008).

Furthermore, the author argues that it is important to differentiate between process maturity and organisational maturity. There are some models that were created for assessing process maturity (the condition of the process in general), such as OMG, and other models for assessing organisational maturity (business process management capability of the organisation), such as CMMI and the models developed by McCormack (2007), and van Looy et al. (2011). However, there are few models that integrate the features of both types of model.

2.6.4 Other maturity models

Subsequently, other maturity models have been developed for different purposes and activities such as innovation, research and development (R&D), supplier relationship, and knowledge management (Boughzala and de Vreede, 2012). However, although there are differences in their structures, software development and software engineering have dominated most of the maturity models, (Wendler, 2012). García-Mireles et al. (2012) conducted a systematic literature review to present the development of maturity models and observed that maturity models differ in their purpose in three respects: first, some models aim to determine the current situation of the organisation (descriptive); the second type of models are able to draw a path for improvement (prescriptive); and the third type of model allows benchmarking through and between industries by comparing organisations in terms of similarities of practices (comparative).

2.7 Systematic review of Lean/Six Sigma maturity models

This systematic review includes Lean, Six Sigma and Lean Six Sigma maturity models that have been published to date in academic journals in the field of Six Sigma, Lean and LSS. Eight well-known databases were searched using search strings such as: [(lean) or (six sigma) or (lean six sigma) or (lean sigma) and (maturity) or (capability) and (model) or (matrix) or (assessment model) or (framework) not (readiness)] and the literature search was limited to the English language only. The research criteria excluded low-ranked journals, books, conferences and grey papers. However, some journals were excluded from the review due to the absence of articles related to the research criteria. This search of journals and databases found that there were no research articles related to LSS maturity/capability to be found before 2002. The results of the systematic review are presented in Table 2.11.

Table 2.11: Findings of the systematic review on Lean/Six Sigma maturity models

Databases	Entries/ papers	Relevant papers
Emerald Insight	7	1
American Society for Quality (ASQ)	3	2
Inderscience	8	0
Taylor & Francis	9	1
ScienceDirect	10	0
Informs	3	0
IEEE Xplore	7	0
John Wiley & Sons	3	1
Total	50	5

The results of the systematic review for the available maturity models in Lean and Six Sigma show that there is dearth in maturity models to measure the current level of maturity, especially for LSS as one approach. Moreover, the available models lack many important components, such as a scoring system, deciding when the stage is completed and when to move to the next stage, linking the model to CSFs, human aspects, and the role of IT.

As Six Sigma and CMMI are complementary, many authors, including Antony and Fergusson (2004); Mahanti and Antony (2006); Murugappan and Keeni (2003); Rao, (2010); Watson (2002) have suggested integrating Six Sigma with CMM/CMMI in the software industry to identify product quality through Six Sigma, while identifying the process capability through CMM/CMMI. They have reported many benefits for this integration, but the research was focused on the software industry and was not generalised for other industries. Other models were developed for Six Sigma maturity assessment, such as those by Li and Lin (2011) and Zhen (2009), However, these models have many limitations, as shown in Table 2.12.

In terms of Lean maturity models, although there are plenty of models developed for Lean maturity and capability assessment, these do not meet the inclusion criteria for this review. This because most of these models were presented in conference papers or online websites with very brief explanation of maturity levels and categories and they were based on researchers' practical experience, with a lack of a theoretical base. The only model for Lean maturity included in this review was developed by Malmbrandt and Ahlstro (2013). This model is based on 34 enablers distributed in 5 levels. However, the model has some limitations, e.g. lack of a scoring system, or guidelines for deciding when the stage is completed and when to move to the next stage, and many other omissions.

In terms of LSS maturity assessment models, a very limited number of models have been developed for this purpose. Shere (2003) suggests integrating LSS principles into CMM, because they are complementary, as both have the same goals for process improvement and both can be applied to develop complex systems. A model recently developed by Watson-Hemphill and Bradley (2012) is based on five categories, which are strategy, projects, resources, training, and culture. The model is also based on the authors' practical experience and has some limitations, as presented in Table 2.12.

Table 2.12: The available maturity models in Lean/Six Sigma and LSS

Reference	Purpose	Background	Limitations
Zhen (2009)	To assess Six Sigma programme maturity in Chinese software industry	Based on Baldrige criteria, Motorola's corporate quality system review guidelines, survey and interviews	-Developed for software industry in China and not generalised for other industries -The model ignored innovation. -The required Six Sigma infrastructure in each maturity level was not explained -Unsatisfactory documentation

Lin et al. (2009)	Integrate CMMI and Six Sigma in a framework to assess auto process maturity	Based on the integration of CMMI and Six Sigma	-Developed for the automobile manufacturing industry -Limited focus on the current level of the process maturity and helping organisations to mature the relative processes of product development and manufacturing in its product lifecycle; therefore, it cannot be used to assess the maturity of LSS -Scoring system is not available in the model
Li and Lin (2011)	Integrate CMMI and Six Sigma in a framework to assess auto process maturity	Based on the integration of CMMI and Six Sigma	-Developed for the automobile manufacturing industry -Limited focus on the current level of the process maturity and helping organisations to mature the relative processes of product development and manufacturing in its product lifecycle therefore, it cannot be used to assess the maturity of LSS -Scoring system is not available in the model
Malmbrandt and Ahlstro (2013)	Operational measures of Lean service	Based on Lean literature: it was then validated through workshops and semi-structured interviews with expert practitioners	-Focus on service sector -Missing important components e.g. scoring system, time needed to move to next level, organisational learning practices and communication.
Watson-Hemphill and Bradley, (2012)	To measure the deployment of LSS	Based on many years of authors' practical experience in the field	-Based on the authors' practical experience -Lack of theoretical base, validity and generalisation -There is no clear definition for each maturity level -Limited to five categories -Missed some important characteristics, such as organisational learning and scoring system -Not user friendly

The results of the review for the available maturity models clearly reveal that there is a need for developing a maturity model for business process excellence that overcomes the limitations of the previous models. Hence, this research presents the development of a LSS Maturity Model (LSSMM) which can be employed by Saudi organisations (as explained in detail in Chapter 7). The development of this model will be an attempt to bridge the research gap which has been identified, which is the absence of a Lean Six Sigma maturity model with which organisations deploying Lean Six Sigma can assess their current maturity level.

2.8 Quality initiatives in Saudi Arabia

Searching the history of quality practices and continuous improvement in Saudi Arabian organisations shows that ISO 9000, ISO 9001, ISO 14001 and TQM have been widely adopted by Saudi private and public organisations (Alsaleh, 2007; Magd, 2006). Many research studies have been conducted to investigate the status of quality practices in general in the country (e.g. Al-Darrab et al., 2013; Alrubaish, 2010). Other research has focused on international standards for quality, such as the ISO series (Curry and Kadasah, 2002; Magd, 2006; Mariotti et al., 2014) and CI methods, including TQM (Al-Sulimani, 1995; Alsaleh, 2007; Curry and Kadasah, 2002), Six Sigma (Alsmadi et al., 2012; Ateekh-ur-Rehman, 2012), Lean (Abdelhadi and Shakoor, 2014; Abdelhadi, 2014) and Lean and Taguchi (Noorwali, 2013). However, little attention has been afforded to Lean Six Sigma as an approach in that country, or even in Middle Eastern countries generally. Little evidence was found for LSS implementation in certain sectors, as shown in Table 2.13. For instance, in the healthcare sector, only three case studies have been conducted in three different public hospitals. The first study was in a health care centre, to reduce waiting time in the vaccination room from 24.5 minutes to less than 10 minutes using tools and techniques from the Lean Six Sigma tool box (El Faiomy and Shaban, 2012). The second study was to improve patient flow in emergency departments (Al Owad et al., 2012). The third study was to streamline the current discharge process of King Khalid hospital (Reddy and Al Shammari, 2013).

In addition, two case studies were published for LSS implementation in the construction sector. The first case presented the implementation of a Lean, Green and Six Sigma framework in the construction sector (Banawi and Bilec, 2014). The second case was published by Bechtel construction, which was conducted to reduce the time for building 405 villas for the community in Jubail Industrial City in Saudi Arabia (Oguz et al., 2012).

The highest number of publications were concerning the oil, gas and petrochemicals industry, with four case studies published by a leading petroleum organisation, Saudi Aramco, and King Fahad University of Petroleum and Minerals (Al-Sadat and Robertson, 2007; Amminudin et al., 2011; Bubshait and Al-Dosary, 2014; Dahlgaard and Dahlgaard-Park, 2006). In the energy sector, two case studies were published for LSS projects. The first one was carried out in a multinational company to optimise the qualification process for vendor inspectors (Bubshait and Al-Hamdan, 2013). The second study was conducted by an engineer (Bhanumurthy, 2012) in Saudi Aramco to identify and reduce defects in the energy system in order to obtain high performance indices which would enable the company to meet the best performing refineries Energy Intensity Index (EII).

Another LSS study was conducted in the media and entertainment sector in the Saudi broadcasting corporation in Riyadh, to increase the employees' safety, decreasing accidents from 25 to seven accidents a year (Alharti et al., 2014).

In the manufacturing sector, only one article has been published on a food distribution SME (Algassem et al., 2014). This clearly demonstrates the shortage of publications in a large country that has 6871 manufacturing organisations specialised in 23 types of industrial activities (Ministry of Commerce and Industry, 2015).

In the higher education sector, King Abdullah University of Science and Technology (KAUST) has been progressing an advanced level of LSS deployment since 2009. However, reports of the LSS projects in KAUST have not been published yet, apart from a conference paper presented in 2012 in Scotland and published in 2015 (Svensson et al., 2015).

It was also important to explore Masters and Doctoral theses in the field of LSS in Saudi Arabia, as this topic is the main focus of this research. The only PhD project found was carried out by Almuharib (2014) regarding the deployment of LSS to enhance the level of service and customer satisfaction in the departure area of King Khalid International Airport in Riyadh. One of the tangible results of this project was a total reduction in passenger waiting time from 54.74 minutes to 34.87 minutes.

Table 2.13: Review of LSS publications in different sectors in Saudi Arabia

Sector	Number of Studies	Reference
Healthcare	3	(El Faiomy and Shaban, 2012; Al Owad et al., 2012; Reddy and Al Shammari, 2013)
Construction	2	(Banawi and Bilec, 2014; Oguz et al., 2012)
Transportation (Airport)	1	(Almuharib, 2014)
Food manufacturing	1	(Algassem et al., 2014)
Oil, gas and petrochemicals industry	4	(Al-Sadat and Robertson, 2007; Amminudin et al., 2011; Bubshait and Al-Dosary, 2014; Dahlgaard and Dahlgaard-Park, 2006)
Energy	2	(Bhanumurthy, 2012; Bubshait and Al-Hamdan, 2013)
Media and entertainment industry	1	(Alharti et al., 2014)
Higher Education	1	(Svensson et al., 2015)
Total studies	15	

The author argues that deploying LSS in Saudi organisations will bring substantial benefits. In Saudi Arabia, there is a strong need for organisations to deploy LSS for greater competitive advantage and achieving operational excellence, especially with the pressure that comes with the legalisation of Foreign Direct Investment in Saudi Arabia. This decision has many advantages for the Saudi market: for example, it creates new job opportunities for Saudi citizens, introduces new technology and maintains economic growth. On the other hand, it puts local Saudi organisations under high pressure, and hence, organisations are striving to improve the quality of their products and services in order to survive in the new market. LSS deployment will help Saudi organisations to improve their competitive position in the market and to stay in competition in the international market (Chakravorty and Shah, 2012; Hilton and Sohal, 2012; Maleyeff et al., 2012).

According to Zairi (1996) and Al-Najem et al. (2013), Arab organisations can generate huge benefits from implementing quality initiatives to help them to address their weaknesses, and eventually make them competitive at an international level. However, Alruwaili (2013) warns that cultural differences need to be acknowledged when borrowing a new management philosophy from a different culture and points out that differences are 'not a bad thing in a managerial world; they just require a bit more work at times'. Most importantly, there is a need to ensure that LSS deployment will be sustained and become mature and not reach a high point of performance then diminish, as have previous CI initiatives deployed in some Saudi organisations e.g. TQM, Lean, and Six Sigma (Alsmadi et al., 2012).

2.8.1 Quality awards and societies in Saudi Arabia

The Saudi government has an important role in encouraging organisations to improve their level of quality. The Government has established a number of quality societies and a quality award for organisations that achieve high levels of quality and organisational excellence. These awards and societies are:

- **King Abdulaziz Quality Award (KAQA)**

This award was established and approved by the King in March 2000. The award is supervised by the General Committee, consisting of experts and national individuals who are specialised in quality (SASO, 2016). Unfortunately, it was found that this is the only available quality award in the kingdom of Saudi Arabia.

- **The Saudi Quality Council (SQC)**

This society was initially established in 1994 as a local branch of the American Society for Quality in the USA. The Society holds more than 5,000 members and it has many roles and responsibilities, which include organising local seminars, conferences, technical meetings and panel discussions related to quality issues in the country, creating a network of quality professionals, and providing quality certification. It has a newsletter that is published quarterly, called "Quality Focus" (SQC, 2016).

- **Saudi Standards, Metrology, and Quality Organization (SASO)**

This body was established in April 1972 as and is directed by a Board of Directors, headed by the Minister of Commerce and Industry. As the sole standardisation body in the Kingdom of Saudi Arabia, it is entrusted with all the activities related to standards and measurements, which include formulation and approval of national standards for all commodities and products, publishing Saudi standards by the most proper means, promoting standardisation awareness, and participating in Arab, regional and international organisations (SASO, 2016).

- **Saudi Society for Quality (SSQ)**

In 2011, the Minister of Commerce and Industry announced the establishment of the Saudi Society for Quality (SSQ), with the aims of improving and developing the quality of services, products, information and the dissemination of the quality culture and its concepts, and to apply those concepts in the public and private sectors, and to contribute in the field of quality. This society has conducted some Six Sigma awareness lectures for anyone interested to learn about Six Sigma (SSQ, 2016).

Investigating the role of KAQA and the quality societies in supporting the LSS deployment level in Saudi organisations shows there is little evidence of significant support provided so far. It was found that the roles and responsibilities of these bodies are to improve the level of quality and enhance business excellence in general, using only the basic methods such as ISO standards. The author argues that they should play a more important role in disseminating awareness of LSS across the kingdom. These societies need to take the responsibility to raise LSS awareness, provide LSS training, and standardise any CI training, based on the country’s culture and market needs. It is also important to learn from other bodies e.g. the American Society for Quality (ASQ) and the European Foundation for Quality Management (EFQM) which support LSS through training, certification, seminars, case studies, and other means.

2.9 Operations management theories

In operations management research, it is essential to create links between existing theories and practice or develop new theories from empirical research and observation (Gupta and Boyd, 2008; Westbrook, 1994). There are many authors who have linked Six Sigma and Lean to theory, including Linderman et al. (2003, 2006), Schroeder et al. (2008), Choo et al. (2007), Arumugam et al. (2013), Hines et al. (2004), Lagrosen et al. (2011), Savolainen and Haikonen (2007), Sony and Naik (2012) and Watson (2001).

The following theories were selected in this research because they are related to either Lean or Six Sigma. However, there is little evidence of their relation to LSS as a single approach (Pamfilie et al., 2012). Therefore, this research contributes to validating the link between LSS and operations management theory by using evidence from empirical research (explained in detail in Chapter 9, section 9.4.1). These theories are presented in the following sections.

2.9.1 Theory of motivation

Motivation is a critical element in employee development, which is a factor in bringing about higher organisational performance (Pamfilie et al., 2012). The theory of motivation has existed since 1911, proposed by Frederick Taylor, who established the importance of employee motivation and stated that 'people work for money' (Taylor, 2004). Since that time, many motivation theories have been developed aiming to increase work productivity through different forms of motivation. These include financial reward, social motivation and appreciation, and meeting the psychological needs of employees (Wiley, 1997), although many author such as Herzberg (1959) and Herzberg et al. (2011), believe that financial recognition for employees is one of the main factors for employees' motivation to work. In 1960, McGregor developed one of the main theories of human motivation and management i.e. X and Y theory (McGregor, 1960). Theory X assumes that employees dislike work, avoid responsibilities where possible and resist change, and hence they need to be controlled by their managers to work hard. Rewards are the most common motivator for such employees. In contrast, theory Y assumes that employees are highly motivated to work and they are committed to the organisation, and hence their managers do not need to control them. However, it is very challenging for managers who have this group of employees to create a culture that supports their employees' desire. Thus, managers should understand their employees' motivation for work in order to manage people more effectively.

2.9.1.1 Types of motivation

According to Herzberg (1959) there are two types of motivation which are:

1- Intrinsic (internal motivation): "Intrinsic rewards are those that an individual receives internally as a result of their involvement in activities that enhance feelings of self-competence, growth, satisfaction, responsibility and autonomy" (Buch and Tolentino, 2006, p. 358).

2- Extrinsic (external motivation): “Extrinsic rewards are those that employees receive from their organization or management as a result of their performance or participation” (Buch and Tolentino, 2006, p. 357).

Theory of motivation is widely used in operations management research, including TQM, Six Sigma, Lean and LSS (ASQ, 2009; Buch and Tolentino, 2006; Gitlow, 2009; Jeyaraman and Teo, 2010; Snee, 2010), and motivating employees has been considered as one of the main challenges to sustain the improvement from LSS projects in Western countries (ASQ, 2009).

The literature shows that both types of motivation are applicable to LSS, as intrinsic motivation gives employees the desire to learn new skills and increase their level of responsibility (Buch and Tolentino, 2006; Gitlow, 2009), whereas extrinsic motivation, e.g. financial reward, is highly motivating in inclining LSS team members towards taking part in future LSS projects (Jeyaraman and Teo, 2010; Snee, 2010).

In addition, other studies have shown that LSS projects contributed to increasing the employees’ motivation to work (Antony and Kumar, 2012; Pamfilie et al., 2012), while the high employee motivation, in turn, leads to the LSS projects’ success and higher organisational performance (Pamfilie et al., 2012). According to Buch and Tolentino (2006), reward and recognition are the main components for successful Six Sigma projects and this was proved in companies such as GE and Motorola. In LSS projects, there are many factors other than financial rewards which motivate employees to work, such as commitment of top management, visionary leadership, good communication and employee empowerment (Antony and Kumar, 2012; Dahlgaard and Dahlgaard-Park, 2006; Gitlow, 2009; Kumar et al., 2006; Pamfilie et al., 2012; Snee and Hoerl, 2003).

On the other hand, lack of motivation and lack of reward for the LSS team for their achievements were cited among the most common factors for LSS project failure (Albliwi et al., 2014; Worley and Doolen, 2006). Lack of motivation was also cited as one of the main reasons for low employee performance and hence low organisational performance (Jeyaraman and Teo, 2010; Snee, 2010). However, there is a lack of empirical studies to identify which types of motivation (intrinsic or extrinsic) are most instrumental for employees to wish to be involved in Six Sigma projects and training in the Middle East (Walley, 2014). There is also a lack of studies that investigate the influence of motivation on LSS deployment and the consequences of lack of financial rewards on LSS progress (Buch and Tolentino, 2006).

A third type of motivation has been subsequently identified, which is organisational motivation. Organisational motivation is related to CI practices and concerns the factors that motivate an organisation to deploy CI practices such as TQM, Six Sigma and others (Buch and Rivers, 2001; Buch and Tolentino, 2006). Hence, organisational motivation was extended to LSS by investigating the most common motivation factors for organisations to implement Lean and/or Six Sigma. These factors have been widely investigated in the literature across different countries, including the USA, UK, Netherlands, India and China. Examples of the common motivating factors for organisations to implement Lean and/or Six Sigma are to increase the bottom-line, to improve quality and efficiency, and to reduce waste (Bisgaard and Does, 2009; Chen and Lyu, 2009; Thomas et al., 2009). One of the main enablers for organisations to achieve these outcomes is high employee motivation (intrinsic and extrinsic) and employee satisfaction.

However, the literature is limited in investigating the factors that have motivated organisations to deploy LSS in developing countries such as Saudi Arabia (Alsaleh, 2007; Alsmadi et al., 2012). Both Alsaleh (2007) and Alsmadi et al. (2012) argue that more empirical studies are needed to understand the factors that stimulate Saudi organisations to deploy quality improvement practices such as Six Sigma. Therefore, one of the objectives of this research is to understand the motivational factors for Lean Six Sigma deployment in Saudi Arabian organisations and compare the findings to those from other countries.

Thus, this research will investigate many issues related to LSS and the theory of motivation within the Saudi Arabian context, including:

- The most applicable type of motivation to support LSS implementation;
- The extent to which extrinsic motivation is used to encourage LSS team members;
- The employees' motivation to be involved in LSS projects and LSS training;
- The most common factors motivating Saudi organisations to deploy LSS.

In this way, this study aims to contribute to establishing an empirical basis, using a survey and interviews to extend the theory of motivation into LSS implementation in Saudi organisations, approached from two angles: those factors that motivate individuals to join LSS teams (intrinsic and extrinsic) and those that have motivated Saudi organisations to implement Lean and/or Six Sigma (organisational motivation).

2.9.2 Organisational learning theory

The history of organisational learning (OL) dates back to 1978 when Argyris and Schön postulated a dual structure for OL (Argyris and Schon, 1978). OL can be defined as "the process of improving actions through better knowledge and understanding" (Fiol and Lyles, 1985, p.803). OL occurs when the employees in the organisation take an effective action to correct their own mistakes (Argyris and Schon, 1978) or when they use learning to solve the common problems that face them (Morgan and Ramirez, 1983; Sony and Naik, 2012). Organisations can select the most appropriate methods for learning according to their needs and characteristics (Sony and Naik, 2012). OL practices can ensure the organisation's long-term success, while leaders are very important element of OL. Schroeder et al. (2008) stress the commitment to learning involved in CI, to avoid individuals and organisations simply repeating former practices, so that change remains superficial, and improvements are not sustained. Faster learning and 'fixing' is a way to become a more sustainable and competitive company. Similarly, Sony and Naik (2012) and Wiklund and Wiklund (2002) argue that effective implementation of an improvement programme is about OL, without which there can be no continuous improvement. The learning curve is the most common technique to measure OL. It links cumulative experience to operational performance: 'Learning by doing' (Easterby-Smith and Lyles, 2011).

The learning behaviours of the people in the organisation, continuous learning by these people and learning faster than competitors combine to create a learning organisation (LO) (Garvin, 1993; Senge, 1990). A learning organisation is "An organization skilled at creating, acquiring, and transferring knowledge, and at modifying its behavior to reflect new knowledge and insights" (Garvin, 1993, p.4), and "is where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free and where people are continually learning how together" (Senge, 1990, p.3). Garvin (1993, p.5) identified five main activities in which a LO demonstrates skills: "systematic problem solving, experimentation with new approaches, learning from their own experience and past history, learning from the experiences and best practices of others, and transferring knowledge quickly and efficiently throughout the organization".

2.9.2.1 Types of organisational learning

There are two types of OL commonly related to operations management research and practices which are:

1- Exploitative learning, which is described in the literature as single-loop or incremental learning. This form of learning tries to solve the problems arising when there are increasing changes but does not address the underlying causes of such problems (Argyris, 1982; Argyris and Schon, 1978).

2- Explorative learning, which is referred to as double-loop or radical learning, looks in more depth into the causes of a problem and uses feedback to reflect on past actions and identify the reasons which led the managers and the employees to use particular procedures, evaluating what was positive and what remains to be improved (Argyris, 1982; Argyris and Schon, 1978).

It was found that organisational learning is closely linked to Lean and Six Sigma as independent methodologies (Hines et al., 2004; Savolainen and Haikonen, 2007; Schroeder et al., 2008; Wiklund and Wiklund, 2002) but also to LSS as a single approach (Manville et al., 2012; Watson, 2001). Learning practices have positive impacts on the effectiveness and sustainability of CI initiatives such as Six Sigma (Schroeder et al., 2008). Organisational learning was found to be a useful framework for assessing Six Sigma readiness, in many studies (Hensley and Dobie, 2005; Lagrosen et al., 2011). In addition, the PDCA method provides a learning cycle for continuous improvement projects (Savolainen and Haikonen, 2007; Roth et al., 1994) which indicates that CI is highly supported by learning. Many studies have investigated the type of organisational learning most applicable to Lean and Six Sigma (Knowles, 2011; Lagrosen et al., 2011; Savolainen and Haikonen, 2007). It has been found that single-loop learning is more popular than double-loop learning, as cited in many studies (Knowles, 2011; Lagrosen et al., 2011; Savolainen and Haikonen, 2007); however, more empirical studies are needed to increase the understanding of how learning practices can support and sustain CI practices in the Middle East (Al-Najem, 2014; Asfour, 2012) and what type of learning occurs in the implementation of CI initiatives such as LSS (Choo et al., 2007; Savolainen and Haikonen, 2007).

Hence, one of the objectives of this research is to assess the extent to which the participating organisations can be described as learning organisations in the context of Lean Six Sigma. This objective indicates the importance of investigating many issues related to LSS and organisational learning theory within the Saudi Arabia context, including:

- The most applicable type of organisational learning to support LSS implementation;
- The possibility of using double-loop learning in LSS projects (Arumugam, 2015; Lagrosen et al., 2011);
- The most common learning practices, as suggested by many authors, e.g. Garvin (1993) and Sony and Naik (2012), and their influence on LSS implementation;
- Using the PDCA cycle with LSS projects as a learning method and a structure for sustaining learning (Savolainen and Haikonen, 2007; Roth et al., 1994).

Therefore, this study initially contributes to establishing an empirical basis using a survey and interviews to link LSS to organisational learning theory and extending organisational learning theory to LSS implementation, based on empirical evidence from some organisations located in Saudi Arabia. This study aims to confirm the positive relationship between LSS and organisational learning, to validate the claim of many researchers regarding the potential of the Six Sigma strategy as a tool to encourage learning and increase competitive advantage (Sony and Naik, 2012).

Secondly, although organisational learning has been a useful framework for assessing Six Sigma readiness in many studies (Hensley and Dobie, 2005; Lagrosen et al., 2011), very few studies have recognised the importance of using organisational learning practices to assess a business process maturity (Dale et al., 2007; Dale and Lascelles, 1997; OMG, 2008). It was found that organisational learning practices have been ignored in most of the available maturity models for Lean/Six Sigma, as shown in table 2.12 (Malmbrandt and Ahlstro, 2013; Watson- Hemphill and Bradley, 2012). Therefore, this study contributes to validating the positive impact of organisational learning theory on LSS maturity assessment by involving organisational learning practices in the maturity model developed in this study, to help organisations to achieve a high level of LSS maturity and to remain successful in the future (Pande et al., 2000).

2.10 The gaps identified in the literature

The purpose of conducting a literature review in research is to highlight the gaps in the current literature which can guide the researcher to formulate the research questions and report other gaps as future research. Based on a systematic review of the LSS literature and the maturity models for business process excellence and LSS assessment, this chapter has identified the key research gap and formulated four research questions (presented in Chapter 1). In addition, other gaps and limitations in the current LSS literature were identified, as shown in Table 2.7. Therefore, as well as the present study, a future research agenda for LSS has been developed in this research and will be presented in Chapter 9.

It was found that there is a lack of both LSS implementation in Saudi Arabia in general, and in most of the sectors of the Saudi economy, and publications on this subject. This gap in coverage includes the airline industry, banking sector, insurance and financial services, general and higher education, and the police force, as well as the manufacturing sector. This clearly shows the need for more studies to map the current status of LSS implementation in Saudi Arabia. The first and only research to investigate the Six Sigma situation in 100 Saudi

Arabian organisations, was in 2012, using a survey questionnaire instrument (Alsmadi et al., 2012). However, that research focused on only on Six Sigma and not LSS. Hence, it is critical to investigate the current status of LSS implementation. According to many authors (Aboelmaged, 2010; Alsmadi et al., 2012; Antony et al., 2005; Antony and Banuelas, 2002; Antony and Desai, 2009; Chakrabarty and Chuan Tan, 2007; Kumar and Antony, 2008, 2009; Nonthaleerak and Hendry, 2008; Thomas et al., 2014; Timans et al., 2012), in order to assess the current status of LSS, it is important to investigate a range of characteristics. These include:

A. Years of deploying LSS.
B. Number of people trained for LSS belts (infrastructure).
C. Level of awareness about LSS (employees' awareness and organisational awareness).
D. LSS methodologies (DMAIC, DFSS, etc.).
E. Impact of LSS on business functions.
F. LSS training (training provider, number of hours, requirement e.g. project, financial saving etc.).
G. Motivational factors for LSS implementation.
H. Benefits gained from LSS implementation.
I. Organisational learning.
J. Critical Success Factors for LSS (CSFs).
K. Common Challenges for LSS implementation.
L. Tools and techniques used under LSS (the most commonly used and least commonly used).
M. Impacts of organisational culture on LSS implementation.
N. Project execution (project selection, number of failed projects, reasons for project failure).
O. Financial benefits.

It is also important to investigate the background of quality and CI practices, including previous quality methods and quality systems used, business process improvement methodologies and quality awards received (Antony and Banuelas, 2002; Kumar, 2010; Kumar and Antony, 2008). These characteristics are empirically investigated within the Saudi Arabian context in Chapters 4, 5 and 6 to answer the research questions RQ1, RQ2 and RQ4, which aim to investigate the current status of LSS in Saudi Arabian organisations, the motivational factors for LSS implementation, and organisational learning practices.

The development of the LSS maturity model is also aimed to bridge another gap in the literature, which is the absence of a LSS maturity model that is applicable for developing countries, and Saudi Arabia in particular. Therefore, RQ3 aims to develop a LSS maturity model for Saudi Arabian organisations based on the available models in the literature and the empirical research presented in Chapter 7.

2.11 Chapter summary

This chapter has provided a brief introduction to Six Sigma, Lean and Lean Six Sigma, including their definitions, aims, tools and techniques. This was followed by two systematic literature reviews regarding LSS and maturity models, respectively. The systematic reviews highlighted the following points:

- There has been a noticeable increase in the popularity of LSS and level of LSS deployment in the industrial world (Gupta et al., 2012), especially in large organisations in Western countries such as the US, the UK and the Netherlands, and in some small and medium-sized manufacturing enterprises (SMEs) in developing countries such as India.
- There are important LSS themes which emerged in this review, which are: critical success factors (CSFs), benefits, motivation factors, limitations, impeding factors and failure factors. The application of LSS methodology in 44 case study organisations in different sectors has been reported to result in significant benefits and around 28 CSFs are cited in this chapter.
- The critical success factors across countries have been found to be quite similar in all the studied countries. However, some differences have been discussed in this study, such as the issue of availability of resources, which was found as a CSF in the UK.
- The review also explored the most commonly used tools and techniques in all the case studies included in this research. Interestingly, the use of Lean tools and techniques, such as VSM, 5S, etc., was more common in most cases, as these tools and techniques are non-statistical, unlike Six Sigma tools and techniques, while the use of the Six Sigma toolkit is more familiar in the American manufacturing sector than in Europe.
- There is a lack of maturity models to assess the level of LSS deployment in developing countries.

The following chapters will deal with the empirical investigation, through an appropriate research design and methodology used to answer the research questions.

CHAPTER THREE
Research Design and Methodology

3.1 Introduction

The aim of this chapter is to present the research philosophy, methods and techniques that were chosen to achieve the research aim. This includes a detailed discussion of the data collection process and the analytical techniques employed. Throughout, the chapter explains the rationale behind these methodological choices.

3.2 Research design

Research design is "the science and art of planning procedures for conducting studies so as to get the most valid findings" (Collis and Hussey, 2003, p.113). Determining the research design gives the researcher a detailed plan which can be used to guide and focus the research. It begins with the choice of research paradigm; this will determine the choice of methodology and hence the data collection methods.

3.3 Research paradigm and philosophy

A research paradigm can be defined as "a set of methods that all exhibit the same pattern or element in common" (Meredith et al., 1989, p.305). There are plenty of different views regarding the most common paradigms that are applied in operations management research. Although scientism and positivism were the dominant philosophies for OM research in Western Europe for some time, it was noticed in the late 20th century that there were clear weaknesses in these two philosophies (Fleetwood and Ackroyd, 2004; Saunders et al., 2009). However, there is no right or wrong way in selecting the research paradigm and the researcher's choice of paradigm will depend on their "philosophies and assumptions about the world and the nature of knowledge and about how research should be conducted" (Collis and Hussey, 2003, p.46).

Research paradigms may be differentiated in terms of their ontology, epistemology, methodology and the research techniques associated with them(Denzin and Lincoln, 2011; Easterby-Smith et al., 2012; Guba and Lincoln, 1994; Meredith et al., 1989).

3.3.1 Ontology

The ontological position of a research paradigm is the assumption it makes about the nature of reality (Easterby-Smith et al., 2012; Guba and Lincoln, 1994; Saunders et al., 2009); that

is, whether reality should be seen as external to and existing independently of the researcher (objective) or whether it should be seen as socially constructed (subjective). This research, which employs a survey questionnaire and the case study method, follows an objective ontology in the first phase and a subjective ontology in the second (the third and fourth phases involved the building of the maturity model).
In the first phase of this research, the survey questionnaire, it was more applicable to look at the social world from an objective angle rather than from the researcher's individual perspective, as an objective approach was preferable for collecting quantitative data (Burke and Onwuegbuzie, 2004; Eriksson and Kovalainen, 2008; Saunders et al., 2009). The researcher was careful not to influence the results during the data collection process (Collis and Hussey, 2003; Saunders et al., 2009) and to focus only on facts and clarification rather than her own interpretations. The aim of this phase was to investigate, in broad terms, the current status of LSS in the participating organisations. In the second phase, a subjective approach was more appropriate, because the data being collected was qualitative (Eriksson and Kovalainen, 2008; Saunders et al., 2009). In this phase, the aim was to gain a more in-depth insight into LSS implementation in five selected organisations. Since the focus was on understanding the perceptions and attitudes of individuals (Lynch et al., 2012; Saunders et al., 2009), the central data collection technique in this phase was through semi-structured interviews.

3.3.2 Epistemology

A research paradigm's epistemological position is the assumption it makes regarding the nature of knowledge and how we learn about reality (Bititci and Ates, 2008; Collis and Hussey, 2003; Easterby-Smith et al., 2012; Guba and Lincoln, 1994). The most common epistemological positions in business research are positivism, interpretivism, critical realism and pragmatism (Saunders et al., 2007, 2009). Which of these the researcher chooses will depend on the research questions he or she is seeking to answer.

3.3.2.1 Positivism

Positivism was developed by a French philosopher, Auguste Comte, in the 19th century (Easterby-Smith et al., 2012). Its key idea is that the social world exists externally, and that phenomena should be measured using objective methods, rather than being inferred subjectively through sensation, reflection or intuition. Although positivism is criticised as over-simplistic, it is widely accepted as an approach for investigating and interpreting the causal relationships between a small number of well-defined constructs (Easterby-Smith et al., 2012). The approach is generally adopted as part of a deductive research strategy, where the aim is to test hypotheses. The relationships between constructs are investigated using quantitative methods such as surveys, experiments and statistical analysis (Burke and Onwuegbuzie, 2004; Eriksson and Kovalainen, 2008; Saunders et al., 2009).

3.3.2.2 Interpretivism

The focus in this approach is on humans as social actors; the researcher seeks to understand what these actors are thinking and feeling, and the meanings they attach to the phenomenon under investigation (Saunders et al., 2009). Interpretivism is generally adopted as part of an inductive strategy; that is, the researcher starts from the data and follows where it leads, rather than being focused on testing theory or hypotheses. Usually associated with qualitative research methods (Burke and Onwuegbuzie, 2004; Eriksson and Kovalainen, 2008; Saunders et al., 2009), interpretivism is the best epistemological approach for those wanting to investigate organisations in-depth as it allows the researcher to address potential concerns about generalisability by employing a combination of interviews, observations and analysis of secondary data (Bititci and Ates, 2008; Easterby-Smith et al., 2012).

3.3.2.3 Critical Realism

"The philosophy of realism is that there is a reality quite independent of the mind" (Saunders et al., 2009, p.114). However, the critical realist believes that: "Our knowledge of reality is a result of social conditioning and cannot be understood independently of the social actors involved in the knowledge derivation process" (Saunders et al., 2009, p.115). The paradigm can thus be seen as a "useful compromise which can combine the strengths and avoid the limitations of positivist and interpretivist paradigms" (Saunders et al., 2009). The focus of critical realism is more on understanding and explanation rather than prediction and it can be adopted as part of either an inductive or deductive strategy (Easterby-Smith et al., 2012).

3.3.2.4 Pragmatism

Many mixed methods researchers and theorists draw strong associations between pragmatism, which is a practical approach to a problem, and the use of mixed methods (Cameron, 2011; Denscombe, 2008; Tashakkori and Teddlie, 2010). The mixed method approach is compatible with the pragmatist paradigm, which posits that different methods should be used, as necessary, to achieve the research aims. This allows the researcher to explore the phenomenon at both the macro and micro level (Tashakkori and Teddlie, 2010).

Positivism and interpretivism were both rejected as unsuitable for this research because positivism assumes that only observable phenomena can and should be researched (Eriksson and Kovalainen, 2008; Saunders et al., 2009), while interpretivism is better suited where the researcher is starting from data rather than theory and literature (Burke and Onwuegbuzie, 2004; Eriksson and Kovalainen, 2008; Saunders et al., 2009). Critical realism was also rejected as unsuitable for this research because it cannot support mixed method research (Saunders et al., 2009). Instead, pragmatism was selected because it allows the researcher to adopt both qualitative and quantitative approaches, and use mixed methods to collect both hard and soft data to address the research questions (Cameron, 2011; Denscombe, 2008; Tashakkori and Teddlie, 2010).

3.3.3 Methodology

Methodology can be defined as "a combination of techniques used to enquire into a specific situation" (Easterby-Smith et al., 2012, p.18). There are a number of methodological approaches, but the most popular are the deductive approach (which starts from theory and helps to understand and explain the phenomenon under investigation) and inductive approach (which starts with data rather than theory and literature and helps the researcher to build theory based on the researcher's observations). Combining inductive and deductive approaches in a single study is known as an abductive approach (Dubois and Gadde, 2002). It is widely practised and accepted in many areas of social science and operations management research (Easterby-Smith et al., 2002; Yin, 2003; Saunders et al., 2007).

This study adopts the abductive approach to address the research questions through adopting the deductive approach in the first phase of the study to collect quantitative data (Collis and Hussey, 2003), where participants were given a survey questionnaire, the design of which drew on the findings from a review of the LSS deployment literature. The inductive approach was then adopted in the second phase to collect more in-depth, qualitative data (Collis and Hussey, 2003). This was done by means of semi-structured interviews with representatives from five case study companies.

3.4 Research strategy

The research strategy is the set of techniques and procedures that are chosen to collect and analyse data; these choices will reflect the researcher's ontological and epistemological assumptions (Verschuren, 2003). Research strategy may be classified as either quantitative or qualitative in nature; a key decision for the researcher is whether to adopt a qualitative or quantitative strategy, or a combination of both (Mason, 2002; De Vaus, 2001).

3.4.1 Qualitative and quantitative research

Qualitative research is "a creative process which aims to understand the sense that respondents make of their world" (Easterby-Smith et al., 2012, p.159). In this approach, the researcher employs data collection methods designed to investigate the subjective, socially constructed meanings attached to the phenomenon under investigation (Bryman and Bell, 2015; Denzin and Lincoln, 2011). This approach is most closely associated with interpretivism, while quantitative research is more closely associated with positivism (Croom, 2009; Easterby-Smith et al., 2012). Quantitative techniques focus on the collection and analysis of numerical data with the aim of testing hypotheses and building on existing knowledge (Collis and Hussey, 2003; Croom, 2009); in other words, they are deductive in orientation. The critical differences between qualitative and quantitative research are presented in Table 3.1.

Table 3.1: Critical differences between qualitative and quantitative research

Research process	Qualitative	Quantitative
Research focus	Understand and interpret	Describe, explain and predict
Principal theoretical orientation	Inductive: generation of theory	Deductive: testing of theory
Epistemological orientation	Interpretivism	Positivism
Ontological orientation	Subjectivity	Objectivity
Literature used	Minor role: to justify problem	Major role: to justify problem, identify questions and formulate hypotheses
Purpose of inquiry	Understanding the interrelationship of different variables	Explanation and control
Sample design	Non-probability; purposive	Probability
Sample size	Small	Large
Data analysis	Descriptive analysis by interpretation of data	Statistical techniques
Data validation	Relies on the participants, the researcher, or the reader	Relies on internal validity, construct validity, external validity and statistical conclusion validity

Research question seeks	Patterns of unanticipated as well as expected relationships	A relationship between a small number of variables

(Source: Bryman and Bell, 2015; Collis and Hussey, 2003: Cooper and Schindler, 2008)

Table 3.1 shows more details about qualitative and quantitative research in terms of their focus, theoretical orientation, ontology, epistemology and also their capabilities and suitability for different purposes. This clearly shows that adopting one approach alone cannot always answer the particular research questions but mixing both approaches would be powerful to collect and analyse data (Denzin and Lincoln, 2011; Tashakkori and Creswell, 2007).

3.4.2 Mixed method research (MMR)

Interest has grown in the use of mixed method research, which allows the researcher to combine two methodological approaches to collect and analyse data (Burke and Onwuegbuzie, 2004; Denzin and Lincoln, 2011; Tashakkori and Creswell, 2007). Gable argues that: "The case for combining research methods generally, and more specifically that for combining qualitative and quantitative methods, is strong" (1994, p.1).

In this study, data collection was carried out using quantitative (survey questionnaire) and then qualitative (semi-structured interviews) methods. Both methods were equally important in answering the research questions and building the maturity model. Collecting the quantitative data took longer (several months to construct the questionnaire, select the sample, finalise and distribute the questionnaire and receive enough responses for analysis), but collecting the qualitative data was more expensive (due to the cost of visiting case companies located in different regions of Saudi Arabia). Figure 3.1 presents the matrix of possible approaches to MMR. As highlighted in the figure, the survey and interviews were given equal status in this study.

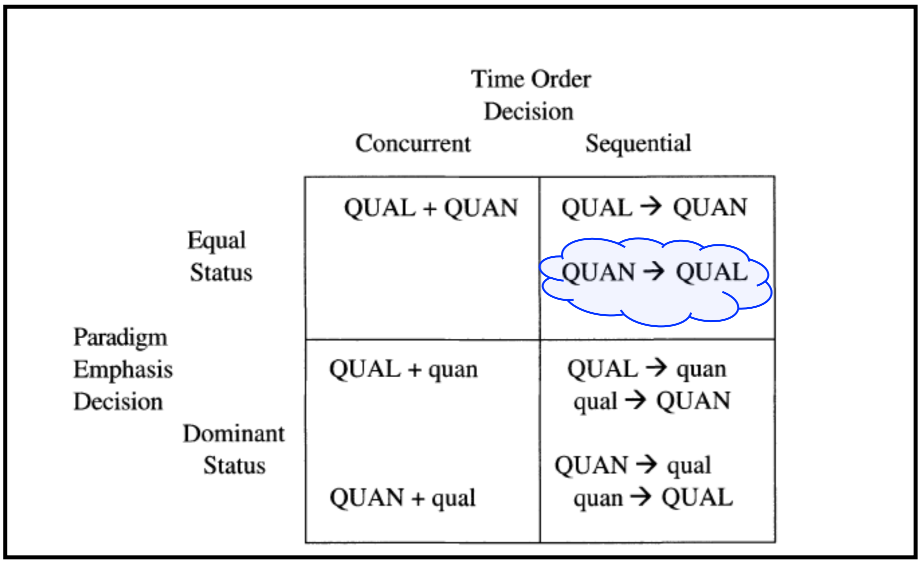


Figure 3.1: Mixed-method design matrix
(Source: Burke and Onwuegbuzie, 2004)

3.4.3 Triangulation

Triangulation is the use of different research approaches, methods and techniques in one study to get a fuller and richer picture. It can overcome the potential bias and sterility associated with the single-method approach; more broadly, if different researchers using different methods arrive at the same conclusions, these conclusions may be regarded as more valid and reliable (Collis and Hussey, 2003; Saunders et al., 2009). There are four types of triangulation: data triangulation, investigator triangulation, methodological triangulation and theoretical triangulation (Easterby-Smith et al., 1991; Barratt et al., 2011; Yin, 2003a; 2014). These may be combined in one study; for example, the researcher may employ both methodological triangulation and theoretical triangulation. Triangulation offers fundamental benefits, such as enhancing research productivity, strengthening qualitative methods and allowing the complementary use of quantitative methods, but it cannot be used to rectify poor research design (Collis and Hussey, 2003). The use of multiple sources of data increases the reliability of the results and the research process (Collis and Hussey, 2003; Tellis, 1997), though Tellis (1997) cautions that the researcher should take into account the cost and practicability of this strategy when deciding whether to incorporate triangulation into the research design. The forms of triangulation used in this study are summarised in Table 3.2

Table 3.2: Triangulation

Triangulation type	Description	As applied in this study
Data triangulation	Data collected at different times or from different sources.	Primary and secondary data were collected from a variety of sources.
Investigator triangulation	Data collected independently by different researchers, allowing comparison of the results.	N/A
Methodological triangulation	Data collected by both qualitative and quantitative research methods.	Quantitative data collected via the survey, qualitative data collected via semi-structured interviews.
Theoretical triangulation	Theory is taken from one discipline such as marketing and used to explain a phenomenon in another discipline such as accounting.	Organisational learning theory and motivation theory were investigated in relation to Lean Six Sigma implementation.

Adapted from: Barratt et al. (2011), Easterby-Smith et al. (1991), Yin (2003a, 2014)

3.5 Methods/techniques

The choice of individual techniques for data collection and analysis (Easterby-Smith et al., 2012) will depend on whether the research is exploratory, descriptive or explanatory in purpose (Forza, 2009; Yin, 2003a). More specifically, it will depend on the nature of the research questions (Bititci and Ates, 2008; Yin, 2014).

Available data collection techniques include the review of documentary sources, case studies, interviews, questionnaire surveys, experiments and observation. This study employs a descriptive questionnaire survey for the quantitative strand of the research, supplemented by the case study strategy for the qualitative strand. As part of the case study, it was necessary to conduct a series of semi-structured interviews with individuals from the case organisations. The case study and survey methods have been widely used by researchers in the areas of Lean Six Sigma and operations management (e.g. Al-Najem et al., 2013; Antony and Kumar, 2012; Antony et al., 2008; Arumugam et al., 2012; Assarlind et al., 2013; Gupta et al., 2012; Hoerl and Snee, 2012; Langabeer et al., 2009; Timans et al., 2011). Numerous doctoral researchers have employed this combination of qualitative and quantitative techniques to investigate Lean/Six Sigma (e.g. Al-Najem, 2014; Arumugam, 2015; Kumar, 2010; Matteo, 2012).

3.5.1 Survey method

The survey method involves "the collection of information from individuals about themselves or about the social units to which they belong" (Forza, 2002, p.155). Surveys may be conducted in several ways, including face-to-face interviews, telephone interviews, or self-completed mail or online questionnaires (Collis and Hussey, 2003; Easterby-Smith et al., 2012; Forza, 2009). They are the preferred method for answering 'what', 'who', 'where', 'how many' and 'how much' research questions (Yin, 2003b) and are useful for collecting data from a large number of people about their opinions and behaviours (Easterby-Smith et al., 2012).

Surveys may be exploratory, explanatory or descriptive. Exploratory surveys aim to examine phenomena that have not previously been investigated, while explanatory surveys seek to explain the causal relationships between variables and test hypothesised linkages. Since this is not the aim of this study, and a number of publications have already discussed Lean/Six Sigma methodology in Saudi Arabia, it was decided that the survey in this research should be descriptive. The aim of the survey was to gather data that would accurately reflect the current status of LSS in Saudi organisations (RQ1) and the factors that motivate these organisations to implement LSS (RQ2). Finally, it sought data regarding organisational learning (RQ4) in the participating organisations.

3.5.2 Case study method

One of the most powerful research methods in operations management is the case study, which is: "An intensive analysis of an individual unit (person or community) stressing developmental factors in relation to environment" (Denzin and Lincoln, 2011, p.301). The case study is a preferred method for answering 'how', 'what' and 'why' research questions and for gaining a deeper, more holistic understanding of the nature and complexity of the phenomenon under investigation (Collis and Hussey, 2003; Voss, 2009; Yin, 2003a,b).

In case study research, evidence – both qualitative and quantitative – may be drawn from a range of sources, including documentation, archival records, interviews, direct observation, participant observation, physical artefacts and questionnaires (Collis and Hussey, 2003; Eisenhardt, 1989b; Yin, 2014). Case studies therefore offer a richer, more complete insight into the unit of study. The researcher may choose to conduct a single case study or multiple case studies, depending on the theoretical propositions of interest (Yin, 2014), although Yin (2014) argues that the multiple-case design yields greater analytical benefits and reliability. In this research, the descriptive multiple-case approach was adopted because it was the best suited to address the research aim; that is, to critically assess the level of LSS implementation across a range of Saudi Arabian organisations and to compare this with LSS implementation in other countries. The descriptive model allowed the researcher to describe the current status of Lean Six Sigma and give a complete and detailed picture (Yin, 2003a), while the use of multiple case studies facilitated theoretical and literal replication and the development of a Lean Six Sigma Maturity Model in the third phase of the research.

3.5.2.1 Interviews

One of the main data collection methods in the case study phase of the research was the semi-structured interview. The interview is an opportunity for the researcher "to probe deeply to uncover new clues, open up new categories of a problem and to secure vivid, accurate, inclusive accounts that are based on personal experience" (Easterby-Smith et al., 2012, p.131). Interviews are the most popular method of data collection in qualitative research. However, although interviews can be highly interesting and enjoyable to undertake, they are a much more complex and exhausting undertaking than developing a structured questionnaire (Mason, 2002). Among their drawbacks, interviews can be expensive and time consuming; they can be difficult to arrange, as the interviewer is dependent on the interviewees' availability; and extensive preparation is necessary to ensure that the conversation will be productive. The interviewee has only a short time to reflect upon their answers and to give in-depth information (Bititci and Ates, 2008; Collis and Hussey, 2003; Easterby-Smith et al., 2012). Notwithstanding these limitations, semi-structured interviews were conducted in the second phase of the research in order to collect rich and in-depth data from individuals in the targeted organisations. They were also used in the third phase of the research to assess those Saudi Arabian companies using the LSS maturity model.

3.5.2.2 Case study protocol

According to Yin, case study protocol is "a major way of increasing the reliability of case study research" (Yin, 2003b, p.67). The protocol is especially important when conducting a multiple case study (to minimise variations in the data collection procedure) (Yin, 2003a, 2003b, 2014), or when multiple investigators are involved (Yin, 2003a). However, the research protocol does not just play a major role in enhancing the reliability and validity of the case study data (Brereton et al., 2008; Perry, 1998; Voss, 2009; Yin, 2003b, 2014) it may also guide the case study analysis and the writing up of the report. Developing the protocol allows the researcher to see in advance what data needs to be collected and how; thus, Voss et al. (2002) and Voss (2009) argue that the core of the protocol is the interview questions, which should be used as a checklist to ensure that the researcher has covered all the intended topics. Yin argues that the following are essential elements of the case study protocol (2003b, p.69):

- "An overview of the case study project (project objectives and sponsorship, case study issues, and relevant readings about the topic being investigated)"
- "Field procedures (presentation of credentials, access to the case study sites, general sources of information, and procedural reminders)"
- "Case study questions (the specific questions that the case study researcher must keep in mind in collecting data, "table shells" for specific arrays of data, and the potential sources of information for answering each question)"
- "A guide for the case study report (outline, format for the data, use and presentation of other documentation, and bibliographic information)".

The case study protocol for this research is presented in Appendix C.1.

3.6 Data collection and analysis

The data collection and analysis process in this research involved a series of steps: sample selection, designing the questionnaire instrument and interview protocol, pilot testing, distributing/administering the data collection instruments to the full sample, and finally, the quantitative and qualitative analyses. These are discussed in the following sections.

3.6.1 Sample selection strategy

A: Survey

Identifying the right target population and selecting a representative sample is critical, as this will determine the generalisability of the results (Collis and Hussey, 2003; Cooper and Schindler, 2008; Gay and Diehl, 1992; Rungtusanatham et al., 2003). Organisations that meet the research criteria may be identified by means of databases (Easterby-Smith et al., 2012), after which the researcher may employ probabilistic sampling methods (e.g. simple random sampling, stratified random sampling, systematic random sampling and cluster sampling) or non-probabilistic sampling methods (e.g. convenience sampling, quota sampling, purposive sampling and snowball sampling) (Collis and Hussey, 2003) to find potential participants. Probabilistic sampling is more likely to produce a representative sample that allows generalisability (Forza, 2009).

In this research, the survey sample was selected by means of systematic random sampling where the researcher can select the sample randomly using relevant database (Collis and Hussey, 2003). The potential population – Saudi organisations (of any size and from all sectors) implementing Lean and/or Six Sigma – were identified from the *Council of Saudi Chambers* database, which includes around 13,000 organisations. More than 500 organisations were contacted to check if they were deploying Lean and/or Six Sigma initiatives. Other organisations were selected because there was some information or data in their websites about Lean and Six Sigma projects had been implemented in the organisation. Organisations that were not implementing either Lean or Six Sigma were excluded, as they would not have been able to complete the questionnaire. From this population, a sample of 400 organisations was selected of companies that had a valid phone number, e-mail address and website, and were prepared to give access to a female researcher (some organisations in Saudi Arabia are only accessible to male employees and researchers). Initial contact was made with the Lean/Six Sigma deployment facilitator in these organisations and his or her assistance requested with the survey (Forza, 2009). It was explained that the questionnaire would target CI practitioners, managers, quality department staff and Lean/Six Sigma team members (i.e. those with a detailed knowledge of Lean and Six Sigma methodology), and the contact was asked to nominate suitable participants. These people were then contacted by phone and e-mail and asked to fill out the survey. Those organisations that agreed to participate were informed at this stage that the researcher would subsequently want to visit them to conduct interviews with some senior managers and staff.

B: Case Study

Numerous authors (e.g. Barratt et al., 2011; Eisenhardt, 1989a; Perry, 1998; Yin, 1994) have highlighted the inappropriateness of random sampling for the case study strategy, especially if the aim is to build theory. However, selecting the case or cases to be studied is one of the most difficult tasks in the research process. Yin argues that: "This task should not simply be a matter of finding the most convenient or accessible site from which the researcher can collect data. The selection process needs to incorporate the specific reasons why the researcher needs a particular group of cases" (Yin, 2003b, p.10). Selecting similar cases helps to show whether a theory can be generalised, but on the other hand, selecting dissimilar cases may aid in the extension or modification of a theory (Collis and Hussey, 2003). The researcher must also choose whether to study single or multiple cases (Voss, 2009). If the multiple-case strategy is selected, the researcher should choose cases that allow replication; that is, one may predict that they will yield similar results (literal replication), or that they will yield contrasting results for predictable reasons (theoretical replication) (Yin, 2003a, 2014). Yin (2014) suggests that the researcher should choose the cases that are most likely to illuminate the research questions, and where data will be easily accessible.

In a multiple-case study, the researcher must also consider how many cases are needed. Closure is reached at the point of theoretical saturation, or when "incremental learning is minimal because the researchers are observing phenomena seen before" (Eisenhardt, 1989a, p.545). At this point, the researcher should stop adding cases. Barratt et al. (2011) and Eisenhardt (1989a) suggest that saturation may be achieved with anywhere between four and ten cases, although it could be argued that doctoral researchers are unlikely to have sufficient time or resources to cover more than four or five. An additional challenge in this study was the difficulty of finding a sufficient number of Saudi-based organisations that were deploying Lean and/or Six Sigma and were willing to participate in the research. The selection of cases followed the survey: that is, those organisations that had indicated a willingness in the survey to participate in the next stage of the research were contacted by e-mail and invited to participate in interviews. Once again, the contact in each case was the Lean/Six Sigma deployment facilitator. Sampling for this part of the study was purposive (i.e. non-probabilistic), with the researcher using her judgement to decide on a suitable sample (Mason, 2002; Yin, 2003a).

In the end, five large organisations from different parts of Saudi Arabia (West, Middle and East) agreed to participate in the subsequent phases of the research. These organisations were from a range of sectors and producing a variety of products/services, adding to the richness of the data (Denzin and Lincoln, 2011; Eisenhardt, 1989b; Voss et al., 2002; Yin, 2003b). These organisations were asked to provide the researcher with signed letters confirming that they had agreed to participate in the research and that they had been informed about the ethical issues. Subsequent phone calls and e-mails explained the research aims, described the project in detail and emphasised the benefits accruing to the company through participation. When informed that the data collection would involve face-to-face interviews, some of the organisations had questions about the nature of the interview questions, the time scale for the interviews and the benefits of participation. The case study protocol, which had been prepared well in advance, was very helpful when it came to answering these questions.

3.6.2 Designing the instruments

A: Survey

The descriptive survey (see Appendix B.2) was distributed using Qualtrics online survey software. The questions for the survey were developed following an intensive review of operations management and Lean Six Sigma literature (see Chapter 2) and brainstorming sessions with CI practitioners. The construct of the questionnaire was adopted from similar studies published by practitioners and academics in field of quality improvement and CI (e.g. Aboelmaged, 2010; Alsmadi et al., 2012; Antony, 2004; Antony et al., 2005, 2008; Antony and Banuelas, 2002; Antony and Desai, 2009; Antony and Kumar, 2012; Chakrabarty and Chuan Tan, 2007; Chiarini, 2013; Douglas et al., 2015; Kumar, 2010; Kumar and Antony, 2008, 2009; Nonthaleerak and Hendry, 2008; Rungasamy et al., 2002; Thomas et al., 2014; Timans et al., 2012). The questionnaire was also reviewed and modified by the researcher's supervisor and Professor Cipriano Forza, who is a leading specialist in OM studies and a lecturer in the European Institute for Advanced Studies in Management (EIASM).

The survey began with a brief introduction outlining the aim of the research, the purpose of the survey and what would be done with the results. The first part of the survey, which was written in English, aimed to gain general information about the participating organisation by means of a series of closed questions. These questions elicited information about the organisation's year of foundation, size, turnover, number of employees, number of employees with Lean Six Sigma belts and the history of its quality practices.

The second part of the survey employed multiple-choice questions to find out more about the nature of Lean and Six Sigma implementation in the business, including aspects such as investment in LSS, number of completed projects, CSFs, number of failed projects and the reasons for failure, motivating factors for implementing Lean/Six Sigma, benefits, challenges, organisational learning and cultural effects. Respondents were able to tick as many answers as applicable, and some questions also offered a 'don't know' or 'other' option; in the latter, respondents were able to give an answer in their own words (Forza, 2002). A nominal (i.e. multiple-choice) scale was chosen rather than an ordinal (forced ranking) interval, as in the Likert scale, or ratio (e.g. fixed sum) scale (Forza, 2009). This scale was chosen because, despite offering more limited scope for statistical analysis, it is the best suited to a descriptive survey (Forza, 2009). The questions were presented in a logical order, moving from general to specific topics (funneling), with filter questions being employed for the complex questions (only respondents who had given a certain answer were directed to these questions). Collectively, the questions in the second part of the survey allowed the researcher to build a clear and detailed picture of the nature and status of LSS implementation in the participating organisations.

B: Case Study

Designing a case study is arguably the most difficult part of the process: the researcher must determine what data are necessary to answer the research questions and draw conclusions (Yin, 2003a), and plan how, where and when these will be collected (Collis and Hussey, 2003). The central method for collecting qualitative data in the case study was the semi-structured interviews, the questions for which were compiled following in-depth analysis of the survey findings. The list, which was also guided by the findings from the literature review, was constructed with the twin goals of addressing the research aims and encouraging a smooth conversational flow (Antony et al., 2014; Frey and Oishi, 1995). The protocol was prepared well in advance of the interviews (Antony et al., 2014; Yin, 2003b, 2014).

The interview protocol, which was also written in English, began with a description of the research purpose, sponsor, and the progress made to date, and a reminder that interviewees could refuse to answer any question or stop the interview at any point. They were also reassured that the findings would be confidential, and that they would remain anonymous (Saunders et al., 2009). This was followed by several broad questions, some of which were open-ended, and then by more specific and detailed questions (Voss et al., 2002). A few classification questions elicited data about the participants' occupation (Collis and Hussey, 2003). The risk of bias was minimised by assuring interviewees that their responses would be kept confidential and that there were no right or wrong answers (Antony et al., 2014; Polit and Beck, 2004). Limiting interviews to no more than 60 minutes also reduced the chance of bias by avoiding interviewee fatigue (Antony et al., 2014; Barratt et al., 2011).

3.6.3 Pilot test

A: Survey

Piloting is essential to ensure that the survey instrument and procedure are adequate, before data collection begins in earnest. Identifying problems at this stage can save the researcher significant effort and time – this is a key consideration for the doctoral researcher, whose time is likely to be strictly limited (Collis and Hussey, 2003). Accordingly, the questionnaire (questions and coding) was piloted prior to full distribution with fifteen individuals from the selected population (these individuals did not participate in the final survey). The pilot group included Lean/Six Sigma academics and practitioners in Saudi Arabia (to test whether the questionnaire matched the objectives of the study), industry experts in Lean/Six Sigma/operations management (to identify any redundant or obvious questions) and target respondents (to provide feedback on anything that might affect respondents' answers). The questionnaire was then modified in light of the pilot study outcomes.

B: Case Study

Here too, piloting provides an important opportunity to review and revise the research instrument (Eisenhardt, 1989b) and to assess the time, effort and other resources that will be required for each interview (Robson, 2002). The final version of the protocol can then be used to guide the data collection process across multiple cases (Gable, 1994). Piloting allows the researcher to refine the data collection plan in terms of both target content and the procedures to be followed (Yin, 2014). The selection of pilot cases should be easy, as the researcher can simply choose cases on the basis of convenience of access (e.g. close geographical proximity); however, he or she should bear in mind that this may create relationships between him/herself and the participants that will not exist in the real cases (Yin, 2014). The report from the case study pilot is similar to the real case study report, although it should also include the key lessons learned about the design of the research and field procedure (Yin, 2014).

In this research, the pilot interviews were conducted with 10 leading academics and practitioners, all of whom had years of experience and deep knowledge in the field of Lean Six Sigma and continuous improvement. The pilot interviews, which lasted for between 60 and 90 minutes, were all recorded. The protocol was then revised, with a number of questions being regrouped and reworded to make them clearer for interviewees.

3.6.4 Data collection

In this stage of the research, the researcher officially starts the empirical activity of the research, collecting the real data that will be subjected to analysis.

A: Survey

The survey was distributed via the Qualtrics online survey system. This system was chosen as, although very advanced, it is easy to use for designing and building a survey and securing data (Forza, 2009). It allows the researcher to modify the survey instrument at any time, shows the participants' locations on a map, exports the results to SPSS and Microsoft Word, and shows the percentage of completed samples and samples in progress. The survey was distributed to 400 organisations in Saudi Arabia by e-mail (addresses were retrieved from the *Council of Saudi Chambers* database). In addition, professional networks such as LinkedIn were used to find organisations that met the sample selection criteria.

Opinions vary on what constitutes an acceptable minimum response rate; Forza (2009) suggests 50%, while Easterby-Smith et al. (2012) argue that a 20% response rate is considered sufficient by many researchers, and the Lean and Six Sigma literature shows that even around 10% is acceptable (Shah et al., 2008 received responses from only 8.9% of their survey sample). This is supported by Collis and Hussey (2013), who argue that researchers using the questionnaire technique should expect a response rate of 10% or less. Given that the literature suggests that Lean and Six Sigma are advanced methodologies that are not widely used in developing countries such as Saudi Arabia, a low response rate was expected for the survey. However, from the 400 distributed surveys, 146 responses were returned, 102 of which were complete (the 44 incomplete responses were excluded from the analysis). This gave a total response rate of 25.5%, which may be considered high (Forza, 2009).

B: Case Study

Interviews were conducted in English with 29 individuals, drawn from different levels of the organisational hierarchy within the five case study organisations. Care was taken throughout the interviews to standardise the process as much as possible to reduce the risk of distorted data; the interviews were all conducted in the same way, with the same questions, and where questions were multiple-choice, interviewees were given a card listing the possible responses. This enabled them to concentrate on giving more data instead of having to remember a list of alternatives (Collis and Hussey, 2003, p.182).

Interview data may be recorded in a number of ways, including pre-prepared record sheets, notes or audio/video recording (Voss, 2009; Yin, 2003a). In this case, the decision was made to use audio recorders (iPhone® and Sony® voice recorder) to ensure that all data was recorded securely. The interviewees were informed before the start of the interviews that they would be recorded for research purposes, and all gave their consent. The audio recording was also supplemented with note-taking as this allowed the researcher to record interviewees' attitude, behaviour and body language. Later, these notes were reviewed in conjunction with the audio transcripts (all interviews were conducted and transcribed in English).

One additional data collection technique was used during the interviews to further investigate some aspects of Lean Six Sigma and organisational learning practices (see Table C.2.3 in Appendix C.2). Interviewees were asked to complete three mini-surveys: the first two of these (developed using the survey outputs) were designed to investigate the perceived importance and actual implementation level of the top five CSFs within the case organisations, and the perceived seriousness of the challenges facing LSS in the Saudi Arabian context. The third asked the interviewees to assess the importance and implementation level of listed critical factors in organisational learning (as identified by Garvin et al., 2008). All three surveys employed five-point Likert scales which, apart from allowing participants to give more discriminating responses (Collis and Hussey, 2003; Easterby-Smith et al., 2012), are simple for the respondent to complete and for the researcher to code and analyse (Collis and Hussey, 2003).

Knowing when to stop adding more cases or interviews is important in case study research; this should be when the researcher has enough data (data saturation) to address the research questions (Voss, 2009). In this case, this point was reached after completing 29 60-minute semi-structured interviews with middle managers and Lean/Six Sigma team members/facilitators, all of whom had received training or been involved in Lean/Six Sigma projects (see Table 3.3).

Table 3.3: Interviewee profile

Organisation	Number of interviewees	Positions
A	10	LSS champion, MBB, HR manager, 2BBs, GB, quality manager and 3 middle managers
B	4	Lean deployment champion, 2 Lean practitioners and quality manager
C	5	Quality assurance manager, 2 BBs, academic and middle manager
D	7	BB, GB, YB, quality project manager, HR manager, 2 middle managers
E	3	MBB (middle manager), BB and GB

3.6.5 Judging the research quality

Designing an appropriate research methodology is essential to ensuring research quality. The literature highlights a number of criteria for assessing the reliability and validity of measures used in the research process (e.g. Bititci and Ates, 2008; Easterby-Smith et al., 2012; Forza, 2009; Mason, 2002; De Vaus, 2001; Yin, 2003a,b). Some of these are discussed below.

A: Survey

In survey research, the quality of the instrument may be assessed by testing its validity (whether we are measuring what we intended to measure) and reliability (the stability and consistency of measurement scores). Lack of validity leads to systematic error (bias), while lack of reliability leads to random error (Forza, 2009).The most commonly used reliability indicator in operations management surveys is Cronbach's α (alpha) (Forza, 2009). The validity of quantitative data relies on both the researcher (the ability to design the questionnaire, wording the questions, piloting the survey, dealing with errors, etc.) and the participants (understanding the questions, reading the questions as worded, giving accurate answers, etc.) (Bryman and Bell, 2015; Cooper and Schindler, 2008).

B: Case Study

Numerous authors (e.g. Denzin and Lincoln, 2011; Eisenhardt, 1989a; Voss, 2009; Yin, 2003b) have observed that the quality of case study research depends on its construct validity, internal validity, external validity and reliability. The design of the data collection process is fundamental, in that it has the potential to enhance all of these elements (Yin, 1994). Thus, careful development of and adherence to a case study protocol enhances reliability (Voss, 2009; Yin, 2003a, 2014), while construct validity is strengthened by using multiple sources of evidence (Yin, 1994). Employing a specific unit of analysis can increase the internal validity of the research, while external validity can be strengthened by investigating multiple cases and comparing the evidence across cases. Voss (2009) argues that using multiple cases generates higher external validity than using a single case. There is a full discussion of how this research meets these criteria in Chapter 9.

3.6.6 Quantitative data analysis

The final part of the survey process is the analysis of the data and presentation of the findings. The most common ways of presenting quantitative survey data are frequency histograms (showing the variation in responses to each question) and bar charts (displaying the percentage of respondents giving each response). Since this research employed a descriptive survey to collect the quantitative data, descriptive analysis was the most appropriate technique to analyse the findings (Forza, 2009).

The unit of analysis (or level of data aggregation adopted) should be determined in the early stages of the research, when the research questions are being formulated (Forza, 2009). The most common units of analysis in operations management research are the plant or company, but individuals, divisions, projects or systems may also be used. Since the purpose of the survey was to gain an initial overview of the current level of Lean Six Sigma implementation in Saudi Arabian organisations, the chosen units of analysis were the organisations and the individuals (from different levels of the hierarchy) within these organisations. These individuals were carefully selected for their experience and knowledge of LSS.

Computer statistics packages such as *Minitab* or *SPSS* (Statistical Package for the Social Science) or spreadsheet programs such as *Excel* are invaluable for processing, summarising and analysing the responses to large-scale quantitative surveys. These computer programs enable the researcher to conduct a wide range of analyses and present the results in the form of tables or charts (Collis and Hussey, 2003). In this research, the survey data was analysed using SPSS (version 21), and the resulting frequencies, crosstabs and mean values were presented in the form of tables, charts and figures (detailed findings are discussed further in Chapter 4).

3.6.7 Qualitative data analysis

The qualitative data for the study was generated from the case studies. In analysing the case study reports, it is important to differentiate between the source of the data and the unit of analysis (Yin, 2014). Defining the unit of analysis is especially important in case study research, because it assists with replication and case comparison (Barratt et al., 2011; Yin, 2003a); once again, how it is defined will depend on the research questions (Yin, 2003a). Yin advises that it is acceptable for researchers to be guided by previous similar research studies when choosing a unit of analysis (Yin, 2003a). A search of previous studies in the fields of operations management, continuous improvement and Lean Six Sigma showed that the most common units of analysis are the organisation, project (e.g. LSS project), individual (e.g. LSS experts) and business unit. In the case studies conducted as part of this research, two units of analysis were employed: the organisation and the themes identified from the review of Lean Six Sigma literature. The data source was the individuals who were interviewed.

The analysis of large amounts of data from qualitative interviews is a challenge in qualitative research (Eisenhardt, 1989b; Yin, 2003a). Software packages such as NVivo facilitate this analysis by creating coding templates and storing data more efficiently. They are also able to merge the data from interview transcripts and any accompanying notes to identify recurring themes. In this study, eight such themes emerged from the NVivo analysis.

The most common approach to qualitative data analysis is described by Miles and Huberman (1994). This comprises three steps:

Data reduction involves "selecting, focusing, simplifying, abstracting and transforming the data" (Miles and Huberman, 1994, p.56). Data reduction can be conducted in parallel to the interview process, allowing emerging themes to be developed in more depth in later interviews (Silversides, 2001). An initial step in the data reduction process is to develop a list of codes prior to the data collection (Miles and Huberman, 1994). In this research, the researcher created a list of codes based on LSS characteristics that were identified in the literature review. This included codes related to: the current status of LSS e.g. implementation, infrastructure, training, awareness, methodologies, tools, benefits, CSFs, challenges, culture, project, leadership, investment, ROI, HR and IT. Other codes used were motivation, learning and maturity model. These codes were also used to create the nodes and themes in NVivo. The data were then used to develop the case study reports which were based on the themes identified in the case study protocol. The cases were documented directly after each visit to ensure that the minimum amount of information was lost.

Data display is defined by Miles and Huberman (1994, p.11) as "an organized compressed assembly of information that permits conclusion drawing and action". Presenting the data in a visual format also helps the researcher to become familiar with each case (Voss, 2009) and to find the unique patterns of each case before the cross-case analysis (Eisenhardt, 1989a;Voss, 2009). Data display methods such as charts, matrices, tables, grids and networks also make it easier for the research audience to see and understand what is happening within or across cases (Miles and Huberman, 1994). The qualitative data gathered in this research is displayed by means of tables, charts and matrices.

Data analysis and drawing conclusions is the final step: within-case analysis is followed (where there are more than two cases) by cross-case analysis. Conducting within-case analysis and writing detailed case study reports increases the researcher's familiarity with each case as a stand-alone entity (Eisenhardt, 1989a) and allows him or her to identify the key themes and unique findings in each case, while cross-case analysis allows the identification of similarities and differences, and common patterns across cases. It also facilitates the comparison and contrast of the key findings among cases (Eisenhardt, 1989b), using the themes identified in the case study protocol or categories identified during the data reduction process. Finally, it enhances the external validity or generalisability of the research findings (Voss et al., 2002). Analysis should lead the researcher to conclusions which address the research questions and achieve the research aims. Since this research includes multiple cases (Eisenhardt, 1989b), the qualitative data were subjected to both within-case analysis (see Chapter 5) and cross-case analysis (see Chapter 6). The characteristics that shape the current status of Lean Six Sigma in the case organisations, such as infrastructure, level of training, benefits generated, commonly used tools and techniques, organisational culture and critical success factors have been combined into eight themes (presented in figure 5.1) which form the base for within-case analysis and cross-case analysis. The focus of the qualitative analysis was to describe the current status of LSS implementation in the selected organisations in Saudi Arabia. It was more aimed at developing ideas/generating hypotheses for future research rather than establishing relationships between variables. Hence, there was no hypothesis proposed nor any attempt made to identify causal relationships between variables.

3.7 Ethical considerations

Ethical considerations are especially critical when the research involves individual participants, in this case, the interviewees. The researcher should plan for their protection before starting the data collection process (Yin, 2014). This can be ensured by being open with interviewees and treating confidential information with care (Lincoln and Guba, 1985; Perry, 1998). Giving feedback to the participating organisations helps build long-term trust as well as increasing research validity (Runeson and Höst, 2009). Thus, the researcher should give participants the chance to see and, if necessary, correct interview transcripts and allow them to keep a copy of the analysed data.

This research adheres fully to the university's ethical guidance and procedures. The Ethics Committee Application form was submitted to the university for approval well before data collection began, and throughout the research process care was taken to protect the wellbeing and privacy of participants. Survey participants were informed that the results would be used for research purposes only, and that involvement in the interviews was entirely optional. All responses were treated with the utmost confidentiality and their anonymity preserved. Both survey respondents and interviewees were informed that they could refuse to answer any questions at any time and for any reason (see Appendix B.1 and C.4). The final results of the research have been shared with the participating organisations, and they have also been sent copies of the case study report and the Lean Six Sigma Maturity Model.

3.8 Summary of data collection design, methods and analysis

This section provides a summary of quantitative and qualitative data collection design, chosen research methods and analysis. The data collection and analysis process in this research involved a series of steps including sample selection, pilot testing, selecting an appropriate unit of analysis, data reporting and insuring the instrument validity. These are presented in table 3.4.

Table 3.4: Summary of data collection design, methods and analysis

Element	Survey	Case study
Type	Descriptive survey	Descriptive case study
Sample selection	- *Council of Saudi Chambers* database of Saudi Arabian organisations - Organisations' websites, professional networks and personal contacts	-Relevant cases selected using the survey results and researcher judgment. -Organisations not interested in being interviewed were excluded
Sample selection methods	Systematic random sampling	Purposive sampling
Pilot testing	Survey questionnaires were piloted by 15 Lean/Six Sigma experts from Saudi Arabia to test the questions' clarity and relevance to the main research questions	Interview questions were piloted by 10 Lean/Six Sigma experts, practitioners and academics (in Saudi Arabia and overseas)
Sample size	102	29 interviews (5 organisations)
Unit of analysis	Individuals and organisations	Organisations and Lean Six Sigma themes

Analysis techniques and software	- SPSS software used for descriptive analysis and statistical analysis - Tables and figures used to display and compare results	- Cross-case analysis - Within-case analysis - NVivo (software)
Data reporting	-Descriptive analysis -Statistical analysis e.g. frequency, crosstab and mean value	-Case study report for each case
Ethical issues	- Results used for research purpose only - No attempt made to identify any individual in the organisation - All responses remain confidential and anonymous - Participants were informed that they could refuse to answer a question or stop filling out the questionnaire at any time and for any reason (see Appendix B.1)	- Results remain anonymous - Research explained in detail including risk and expected benefits to participants
Validity	-Piloting of survey questionnaire	- Adherence to case study protocol (see Appendix C.1) - Piloting of interview questions - Interviewees were asked to comment on drafts of the case study report
Triangulation	- Data triangulation - Methodological triangulation - Theory triangulation	- Data triangulation - Methodological triangulation -Theory triangulation

The research involved five phases of data collection (see Figure 3.2). Phase one was to collect secondary data through a systematic literature review. Phase two employed a quantitative survey, the results of which were subjected to descriptive and statistical analysis. These findings were then triangulated with those of the qualitative research conducted in the third phase, which involved using case studies and semi-structured interviews to further investigate the phenomenon of interest. The outputs of the first three phases were used to develop a Lean Six Sigma Maturity Model (LSSMM) in the fourth phase. Finally, the fifth phase was aimed at testing the validity of the developed model in five organisations in Saudi Arabia.

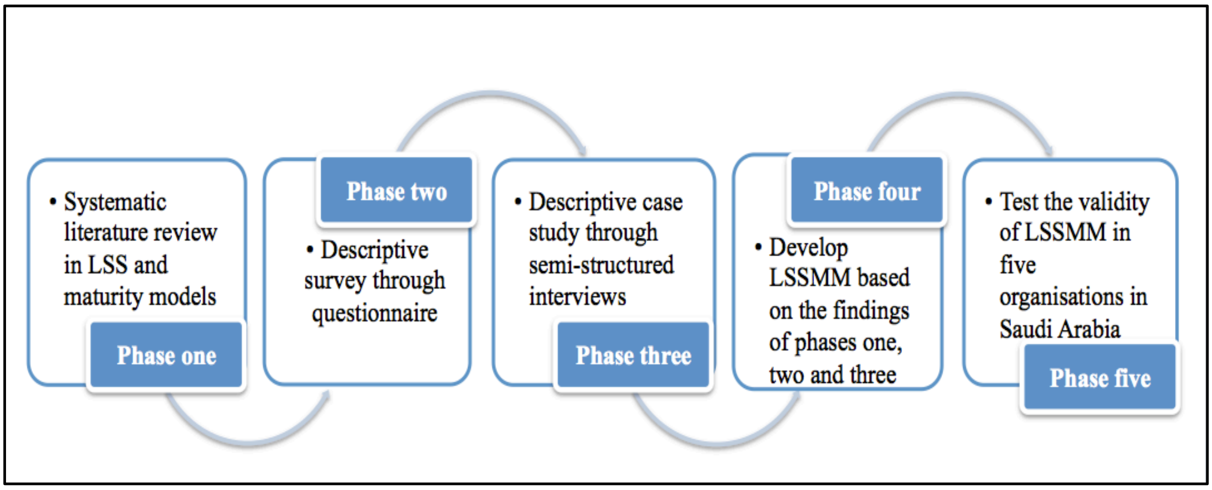


Figure 3.2: Summary of data collection phases

3.9 Chapter summary

This chapter has presented a detailed discussion of the research design, from the choice of philosophical paradigm and research strategy to the methods selected for data collection and analysis. It has justified the choice of the mixed method approach combining qualitative and quantitative instruments, and explained how the combination of questionnaire survey and case study/semi-structured interviews allowed the researcher to address the main research questions within the available time and resources: that is, how the survey provided a general overview of quality practices in Saudi Arabian organisations, particularly Lean Six Sigma, while the case studies allowed a more in-depth investigation of the status of and issues surrounding LSS implementation in five large organisations. Having discussed the methodology, the thesis now turns to the presentation and analysis of the results, starting in the next chapter with those from the quantitative survey.

CHAPTER FOUR
Survey Data Collection and Analysis

4.1 Introduction

This chapter is based on a descriptive survey questionnaire which has been derived from two systematic literature reviews published in IJQRM (Albliwi et al., 2014) and BPMJ (Albliwi et al., 2015), presented in Chapter 2. The purpose of the survey was to critically assess the current status of Lean Six Sigma implementation in Saudi Arabian organisations, investigate motivational factors for Lean and Six Sigma deployment, and investigate the organisational learning practices that support LSS in Saudi organisations.

The survey was designed to consist of two parts: the first part of the survey aimed to gain general information and background about the participating organisation, including its size, year of start-up, turnover, number of employees, number of employees holding Lean Six Sigma belts, and history of other quality management/improvement practices. The second part of the survey aimed to find out more about the nature of Lean and Six Sigma implementation in the business, including aspects such as motivational factors for implementing Lean/Six Sigma, benefits gained, challenges for the implementation of Lean/Six Sigma, organisational learning level, cultural effect.

The survey analysis was conducted in SPSS Statistics software version 21 and Microsoft Excel. Details of the survey design, piloting the questionnaire, sampling method and criteria, distribution of the questionnaire, and judging validity and reliability were presented in Chapter 3.

This chapter reports the response rate and key findings from the survey, including demographic information about participants, the history of quality practices in the participating organisations and the current status of LSS in Saudi Arabian organisations.

4.2 Findings from the survey

From the analysis of both parts of the survey, a clear picture was obtained of the nature of LSS implementation in the participating organisations. In addition, this guided the following stage of data collection, which involved a case study with 29 semi-structured interviews in 5 selected organisations in Saudi Arabia, which will be reported in Chapter 5.

4.2.1 Demographic information

The first part of the survey gathered information regarding the sectors in which the participants were operating: these varied greatly, from private to public, and included manufacturing (23%), higher education (20%), oil and petrochemicals (20%), food and drugs (11%), banking (8%), harbour services (3%), airlines (2%), city councils (2%), construction (2%), engineering (2%), internet solution services (2%), public development authorities (3%) and training services (2%). The year of establishment of these organisations also covered a long span, from 1930 to 2013, which contributes to the richness of the results.

In terms of size of the organisations, only 10% of respondents worked in organisations with less than 500 employees (which were not SMEs); the rest worked in large organisations with over a thousand employees. In addition to the size of the organisation, participants were asked about their organisations' annual turnover and the results are shown in Figure 4.1.

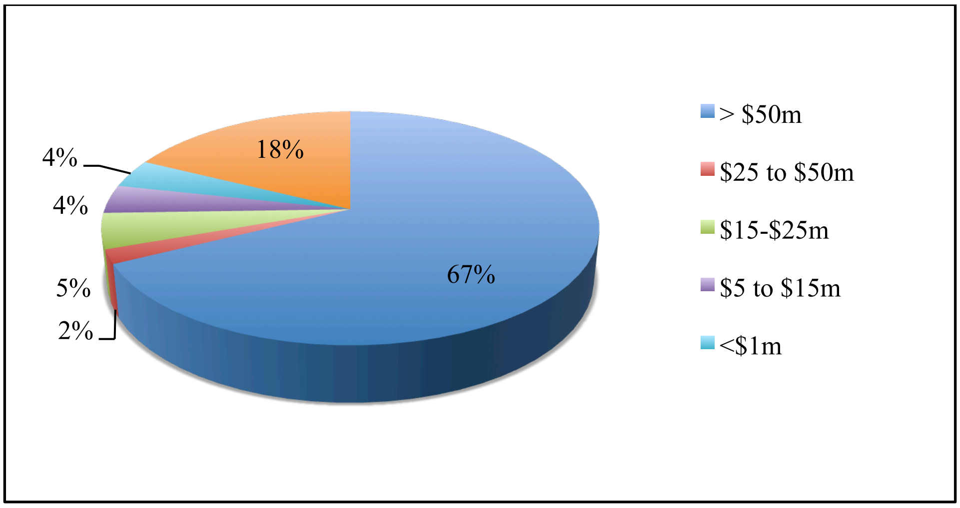


Figure 4.1: The annual turnover of the participating organisations in USD ($)

The figure above illustrates that most of the organisations from the study have a turnover of over $50M. Revenue could be considered a factor influencing the investment on CI initiatives and, thus, a point of consideration for the analysis of the survey results is whether differences exist between organisations with high or low turnover or zero turnover, as in the case of public institutions.

The sample of respondents to the survey included people from different areas within the organisation: business excellence, customer service, engineering, IT, production, project management and quality, and from different levels in the hierarchy: CEOs, senior managers, mid-level managers, staff and the LSS teams. Details of the participants' positions are presented in Table 4.1.

Table 4.1: Participant positions

Positions	Number
CEO/ Director/ GM	10
Departmental head	17
Quality manager	8
Assistant manager	8
Team leader	17
Supervisor	8
Staff	25
Other (confidential)	9
Total	102

Of the LSS certified participants, around 81% of the respondents held LSS belts, including 5 Champions, 5 MBBs, 22 BBs, 34 GBs and 13 YBs. The rest of the respondents were either in training (9) or quality managers (8) who had not received LSS at that point. Some of the respondents (6) preferred to keep their training confidential.

4.2.2 History of quality practices

The respondents were asked whether there was a quality department in their organisations: 72.5% answered ‘yes’ and 27.5% answered ‘no’. This insight is a valuable starting point to differentiate CI initiatives between different organisations, as it enables the approach to the selection and implementation of the CI initiatives to be distinguished between the two groups.

4.2.2.1 History of CI methodologies

Historically, it was found that, within a third of these organisations, the approach to continuous improvement had entailed the adoption of Lean and Six Sigma programmes, without deploying any previous CI initiatives, as shown in Table 4.2.

Table 4.2: History of CI methodologies by sector

Continuous improvement methodology	Percentage	Sector
Kaizen, Lean, Six Sigma and TQM	26%	Private
Lean, Six Sigma and TQM	13%	Private
Six Sigma and TQM	9%	Private (3%) and Public (6%)
Lean Six Sigma	22%	Private (8%) and Public (14%)
Kaizen, Lean and Six Sigma	4%	Private (2%) and Public (2%)
Kaizen, Six Sigma and TQM	2%	Private
Kaizen, Lean and TQM	8%	Private (6%) and Public (2%)
Kaizen and Six Sigma	2%	Private
Lean and TQM	2%	Private
Six Sigma	12%	Public

The other two thirds indicated that they used TQM, Kaizen or both as the foundation for their Lean and Six Sigma programme. This finding could lead to the conclusion that TQM and Kaizen are well recognised by many Saudi Arabian organisations, particularly those in the private sector. However, notwithstanding the recognition of these techniques and the interest of managers in using new forms of quality tools (Alsaleh, 2007), the literature indicates that the implementation of TQM has faced many obstacles in Saudi Arabia such as the lack of a well-defined process, the lack of effective communication and the diversity of the customers (Al-Shafei et al., 2015).

Table 4.2 also shows that private sector organisations are more familiar to CI practices than their counterparts in the public sector. There are a number of reasons for this phenomenon, such as the nature and policy within each sector or whether the person championing change is a leader or a manager. A clear example of the former is the differing perceptions of job security. While in the public sector being made redundant for poor performance evaluations is highly unlikely, in the private sector job security greatly depends on performance and customer satisfaction. Moreover, the duality between managers and leaders also seems to be sector dependent, as leaders are more likely to drive change in private organisations while managers are more dominant in public organisations (Al-Qahtani and Al-Methheb, 1999; Drummond and Al-Anazi, 1997).

To complement the historical approach to CI methodologies, the participants were questioned about the use of other business process improvement methodologies, such as Business Process Management (BPM), Theory of Constraints (TOC) and Business Process Reengineering (BPR). Table 4.3 shows that these practices were more common amongst the oil and chemical industries than in other sectors. Regardless of the size of the organisation, BPM and BPR were used in a quarter of organisations from the sample. Furthermore, 6% of the participants (particularly those whose parent companies were based in Western countries) used methodologies internal to their organisation in addition to those already mentioned.

Table 4.3: Business process improvement methodology

Business process improvement methodology	**Percentage**	**Sector**
BPM, BPR and TOC	14%	Private
BPM and BPR	25%	Private
BPM and TOC	2%	Private
BPM	39%	Private (23%) and Public (16%)
BPR	7%	Private
TOC	3%	Public
None	10%	Private (4%) and Public (6%)

For some authors, like Breyfogle (2003), there are clear benefits to the integration of ISO standards with LSS. This view appears to be shared by most organisations in the study, who implemented ISO 9001 as a starting point for other continuous improvement methodologies such as TQM and LSS. Approximately one third of the organisations used ISO 9001 as a quality management system standard; additionally, half of the participants implemented other ISO standards: to reduce the environmental impact (ISO 14001), for Six Sigma (ISO 13053), and for health and safety in the work place (OHSAS 18001). The last of these was commonly applied in the manufacturing and oil industries in Saudi Arabia.

From the organisations within the public sector in the sample, 15% started to deploy LSS as a basis for CI without ISO certifications, as shown in Table 4.4. In contrast, only one organisation implemented multiple ISO standards, including the ISO 50001 for energy saving, following the practices of its parent organisation in France.

Table 4.4: Quality system/environmental management system

Quality system/environmental management system	Percentage	Sector
ISO 9001	32%	Private and Public
ISO 9001 and ISO 14001	15%	Private and Public
ISO 9001, ISO 14001 and ISO 13053	18%	Private
ISO 9001 and OHSAS 18001	10%	Private
ISO 9001, ISO 14001 and OHSAS 18001	8%	Private
ISO 14001	2%	Private
None	15%	Public

ISO, in all its different versions, appears popular in Saudi Arabian organisations, being well recognised by both public and private organisations alike. Data from an ISO survey shows the rising interest in ISO standards, since the number of Saudi Arabian certified organisations increased from 10 in 1993 to 2,189 in 2012. Yet this figure is small in comparison to circa 76,775 organisations registered in the country (according to the last available survey from the Ministry of Commerce and Industry in 2012) meaning that only 3% of Saudi Arabian organisations are ISO 9001 certified.

The successful implementation of CI initiatives can lead to achieving quality awards, (Barney, 2002; Breyfogle, 2003; Harry and Schroeder, 2000; Snee, 2010; Taghizadegan, 2006). It was, thus, essential to explore whether any of the participants' organisations had won awards as a result of CI deployment. The participants were asked whether their organisations had won any local awards, such as the King Abdulaziz Quality Award (KAQA), or international awards such as the Business Excellence Award of the European Foundation for Quality Management (EFQM), Malcolm Baldrige National Quality Award

(MBNQA), the Deming Prize, or any other. The results in Figure 4.2 show that one fifth of the organisations had won a local award, KAQA, and another 21% had won the EFQM award. These results indicate that, in spite of having CI practices in place, some organisations had yet to achieve the level of quality required to receive an award.

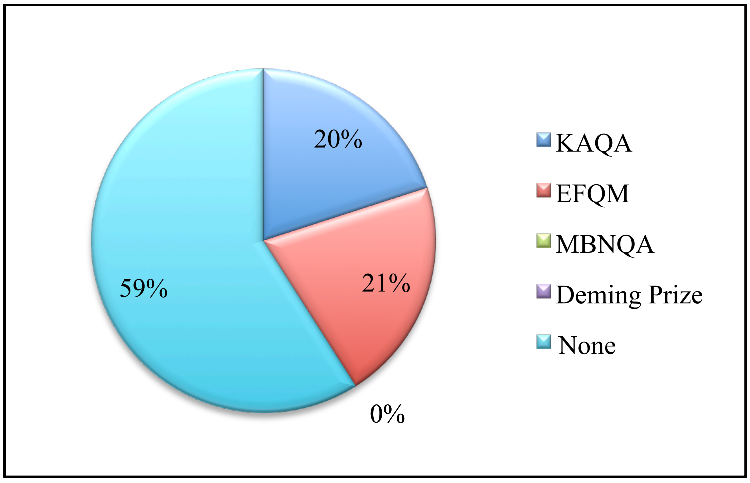


Figure 4.2: Quality awards

4.2.3 Current status of Lean Six Sigma in Saudi Arabian organisations

This section of the chapter addresses RQ1 and investigates the issues related to LSS practices. In order to assess the current status of LSS in any organisation, it is important to investigate many characteristics that emerged in Chapter 2 (see section 2.10), including the following key points.

4.2.3.1 Years of deploying Lean, Six Sigma and LSS

The longest times of implementation were 12 years for Six Sigma, in a manufacturing organisation, and 10 years for Lean, in an oil producing organisation, both of which are large organisations and have joint ventures with foreign partners leading the initiative.

Almost a third of the organisations were reported to have implemented Lean for a number of years (between 1 and 10) before adopting Six Sigma to support it. In contrast, 10% of the organisations—all in the private sector—had implemented Six Sigma for a number of years before adopting Lean. An additional 25% of the organisations—14% public and 11% private—had implemented LSS as one approach. The remaining 35% of organisations deployed Lean (1-6 years) or Six Sigma (1-3 years) in isolation.

4.2.3.2 Number of people trained for LSS belts (infrastructure)

According to Harry and Schroeder, (2000), Six Sigma training should be delivered to at least 50% of the organisation's staff in order to drive change in the business and increase profits. However, in spite of the participants concurring with the author that training and education are critical to LSS success, the proportion of trained individuals in the sample is much lower than that reported in the literature and for Western organisations, as reported in the sections that follow.

1- Number of champions:

It was observed that the vast majority, 74%, of the organisations, regardless of their size, had only between 1 and 5 champions, while an additional 5% had between 6 and 10 champions (among 5,100-10,000 employees). Only 2% had more than fifteen champions, all of which were large organisations with above ten thousand employees, and nearly a fifth reported that there were no LSS project champions in their organisations. This last finding contrasts with the information reported in the literature where it is stated that the champion could be the CEO or the vice-president of the organisation — individuals who have the knowledge to lead the initiative. Examples of this are corporations like GE, Honeywell or Motorola (Antony and Banuelas, 2002).

2- Number of MBBs:

As with the number of champions in the organisation, the number of certified MBBs in Saudi Arabian organisations is lower than reported in literature and belt theory, which suggests a target of one MBB for every 15-20 BBs (Voehl et al., 2013).

A large proportion of the sample, 43%, reported that no LSS MBB representative was available in their organisations. An additional 44% reported having between 1 and 5 MBBs in their organisations, which varied in size between three hundred and ten thousand employees. There were 6-10 MBBs in an additional 8% of the sample, comprising organisations between 5,100 and 10,000 employees, while a final 5%, averaging in size above 10,000 employees, indicated having 15 MBBs in their organisation.

3- Number of BBs:

The literature suggests that the ideal ratio of BBs is 1 BB for every 100 employees (Breyfogle, 2003; George, 2003; Harry, 1998; Harry and Schroeder, 2005; Karthi et al., 2011; Laureani and Antony, 2012; Voehl et al., 2013). This could enable the organisation to reach

6% cost reduction per year (Harry, 1998). Table 4.5 shows the ratio of Black Belts to the total number of employees in the sample. The results reveal that only 18% of the participants reported a ratio of BBs in their organisation of 1:50, which is in line the recommendations found in the literature, whereas 69% of the sample indicated that the ratio of BBs to the number of employees is very low. An additional 13% of the participants disclosed that there were no trained BB employees within their organisations and that the projects and initiatives were carried out by GBs or YBs and external consultants, where available. From the latter group, some stated that their organisations were in the process of building their LSS infrastructure and BBs were still in the training stages; and a small proportion of the organisations stated that they had little adoption of LSS as *ad-hoc* projects, hence they did not yet employ full-time LSS Black Belts.

Table 4.5: The ratio of Black Belts to the total number of employees

Ratio of BB to employee number	Percentage of participants
1 BB for every 50 employees	18%
1 BB for every 300 employees	26%
1 BB for every 1000 employees	8%
Only 1 BB available in the organisation	15%
Only 2 BBs available in the organisation	20%
No BBs available in the organisation	13%

An additional consideration to factor in is the proportion of employees who left the sponsoring organisation after receiving LSS training. From the sample, 10% of participants stated that trained employees had abandoned the organisation upon completion of their training, which represented a major loss for the sponsor organisation. The reasons behind this phenomenon have not been the focus of this research, thus further work is required to understand the motivating factors for employees leaving, and whether the sponsor organisations should receive compensation for the training investment.

With regard to these two levels of expertise, it was noted that 9% of the organisations still lacked both BB and MBBs. These organisations are considered to be beginners in LSS, who have so far relied on a champion to lead LSS and prepare the organisation for the CI journey.

4- Number of GBs:

The literature suggests that there should be 20 GBs for each BB (Harry and Schroeder, 2005; Karthi et al., 2011) or 5 GBs per 100 employees in the organisation (Hoerl, 2001). Some scholars even suggest that all middle managers should be trained for GB and everyone should

be trained for a GB to receive promotion (Hoerl, 2001).
However, within the sample, 73% of the participants indicated that in their organisation fewer than 15% of the employees had trained for GB, while only 5% of respondents indicated that their organisation had around 60% GBs, all of whom belonged to a large organisation with more than ten thousand employees.

5- Number of YBs:

Following the trend already observed, 90% of the participants reported that their organisations had fewer than 15% YB certified employees and the remainder had less than 30%. These results indicate that YB training is not a priority for Saudi organisations, in spite of the fact that the literature suggests that all employees should attend awareness sessions and preferably be YB certified to contribute in changing the organisational culture (Gupta, 2005).
Overall, it was observed that these Saudi Arabian organisations lacked trained employees, more so in public and local organisations than in multinational corporations, where the recommended numbers of LSS belts were available.

4.2.3.3 Level of awareness about LSS

For this study, the awareness in Saudi Arabian organisations was evaluated at two levels: the practitioner's awareness and the organisation's awareness. It is worth clarifying that the level of awareness of LSS could be different to the level of implementation. For example, a participant could rate themselves as fully aware about LSS, meaning that they have knowledge of or experience in LSS; however, that does not necessary reflect the level of LSS implementation within the organisation they work for.
In this study, the Likert scale was used to test the two levels of awareness, using a 5-stage technique rating from 1 = not aware to 5 = fully aware. The results are presented in Figure 4.3.

1- Participants' awareness

Figure 4.3 clearly shows that all respondents had some knowledge of LSS, which ensured that the entire sample could understand the survey questionnaire well enough to provide suitable answers the questions, preventing deviations or inconsistencies due to lack of knowledge or misunderstanding of concepts.

2- Organisations' awareness

Overall, the organisation's level of awareness was reported to be much lower than the participants' own awareness, and over 10% believed that their organisation had little or no awareness of LSS.

It was interesting to find that some organisations with little awareness of LSS counted GBs and BBs amongst their employees. This insight was further investigated in the interview phase presented in Chapter 5, but the hypothesis is that they were hired to create awareness and support the deployment of LSS.

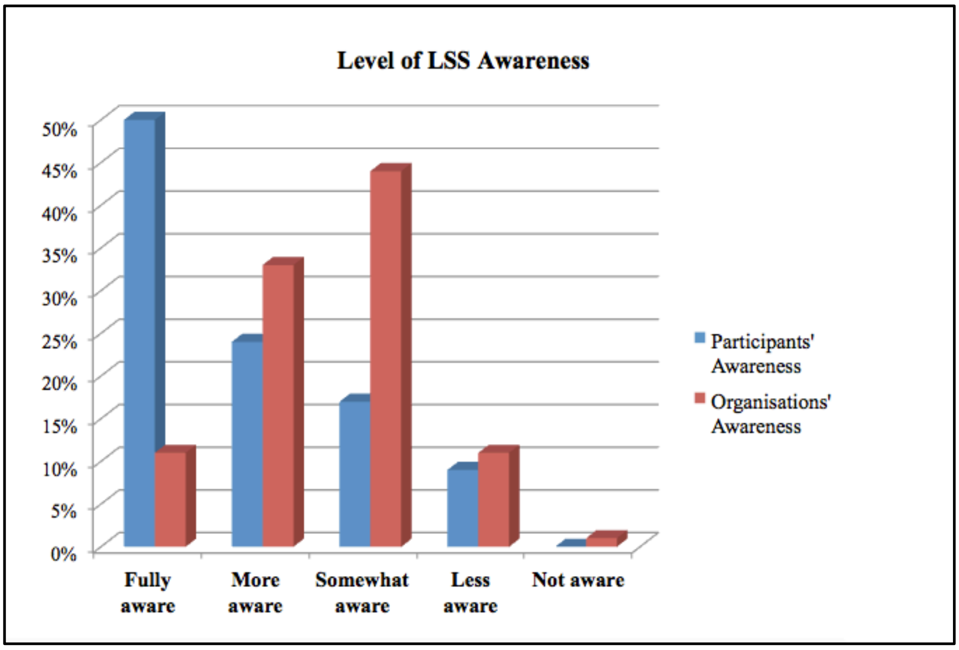


Figure 4.3: Comparing participants' and organisations' awareness about LSS

4.2.3.4 LSS methodologies

There are several methodologies for the implementation of LSS in an existing system, such as DMAIC (Define, Measure, Analyse, Improve, Control) or PDCA (Plan, Do, Check, Act) and also other methodologies for Design for Six Sigma (DFSS), which include DMADOV (Define, Measure, Analyse, Design, Optimise, Verify) and IDOV (Identify, Design, Optimise, Validate).

No consistent preference towards the use of any particular methodology over another in the participating Saudi Arabian organisations was found in this study. One quarter of the organisations were using Lean and Six Sigma tools under the DMAIC methodology, 11% were using PDCA only—without the implementation of the Six Sigma approach, using instead Lean and TQM—and 49% were using both methods as a framework for problem solving. Furthermore, 8% of participants used LSS methodologies combined with one DFSS methodology and 2% used the four methodologies at the same time, which is not the standard approach for LSS deployment. The latter could be explained both by a lack of understanding of the use of LSS methods or as a result of failed attempts to use one methodology, thus moving on to the next one.

4.2.3.5 Impact of LSS on business functions

In spite of the low levels of awareness or implementation of LSS, the respondents highlighted some functions within their organisations where operations had improved with the use of this methodology. These were:

1- Customer service.
2- Administrative processes.
3- Production processes.
4- Supply chain.
5- Information systems.

Additionally, they reported that other functions, such as HR, finance, sales and marketing had also seen the benefits of LSS, but on a smaller scale than those listed above.

4.2.3.6 LSS training and education

There are numerous ways in which an employee can obtain knowledge about quality improvement methods, tools and techniques. In the sample for this study, one quarter received in-house training, while a similar proportion (20%) were sponsored to receive LSS training from external institutions. Among the remaining participants, the source of LSS knowledge acquisition varied between: independent learning (13%), via the Internet (10%), conferences and workshops (8%), distance learning (1%) and other learning methods, such as postgraduate degrees.

More details about training, including the training provider, hours of training, and the nature of projects will be investigated in the next phase of this research.

4.2.3.7 Benefits gained from LSS implementation

The benefits gained from the implementation of LSS in the Saudi Arabian context, as reported by the participants, are shown in Table 4.6. As expected, these benefits are similar to those cited in the literature related to Western countries (Albliwi et al., 2015). However, in contrast to the increased profits and financial savings reported for Western countries, increased customer satisfaction was at the top of perceived benefits for Saudi Arabian organisations.

Table 4.6: Comparison of the top five benefits

Saudi organisations	Literature
1. Increased customer satisfaction	1. Increased profits and financial savings
2. Reduced cycle time	2. Increased customer satisfaction
3. Improve product and process quality	3. Reduced cost
4. Reduced cost of quality (defects, scrap, rework, repair, etc.)	4. Reduced cycle time
5. Reduce waste in the process	5. Improved key performance metrics

The priorities in the implementation of LSS for Saudi Arabian organisations focus more around customer satisfaction, the quality of the products or service and cycle times than on financial benefits and increasing the bottom-line. This trend was previously reported in literature by Alsmadi et al. (2012), although their sample was limited to 15 organisations.

The evolution of technology and media has changed the focus and behaviours of consumers around the world, but particularly in Saudi Arabia. The more recent openness to the global markets, initiated when Saudi Arabia joined the World Trade Organisation (WTO) in 2005, has augmented the levels of competition to an international level and, therefore, customers have become more demanding of high quality product and service offerings (Al-Maghrabi and Dennis, 2011). To meet the ever increasing demands and to maintain their strength and presence in the local and international market place, Saudi Arabian organisations have been motivated to focus on quality and customer satisfaction (Alsmadi et al., 2012).

4.2.3.8 Motivational factors for LSS deployment

The key motivating factors to adopt LSS differed from one organisation to another; nevertheless, trends were observed, the top three factors being the need to reduce time, to improve the quality of the product and process and to improve process efficiency and effectiveness. Slight differences between the priorities of Saudi Arabian organisations and those of Western countries were observed. These are presented in Table 4.7.

It is evident from the results that the most common motivating factors and perceived benefits of the implementation of an LSS initiative are to reduce time, and improve quality and efficiency, all of which bring overall benefits to the business; nevertheless, some challenges in the implementation process remain that cannot be explained by misaligned or unmanaged expectations (Albliwi et al., 2014).

Table 4.7: Comparison of the top five motivational factors

Saudi organisations	Literature
1. To reduce time (cycle time, lead time, etc.)	1. To reduce the cost of quality (e.g. cost of poor quality, production cost)
2. To improve product and process quality	2. To improve product and process quality
3. To improve process efficiency and effectiveness	3. To increase customer satisfaction, attraction and loyalty
4. To reduce defects in all business processes	4. To improve process efficiency
5. To reduce the cost of quality (e.g. cost of poor quality, production cost)	5. To increase the bottom-line

In addition to the motivational factors for organisations to deploy LSS, it is also important to investigate the motivational factors for the employees who are involved in LSS projects and implementation. More details will be available in the next chapter based on interviews with LSS team members, to understand their motivation for using LSS as a business process improvement strategy.

4.2.3.9 Lean Six Sigma projects and organisational learning

Understood as the process of improving action through better knowledge and understanding (Fiol and Lyles, 1985, p. 803), organisational learning (OL) is closely linked to Lean and Six Sigma as independent methodologies (Hines et al., 2004; Savolainen and Haikonen, 2007; Schroeder et al., 2008), but also to LSS as a single approach (Manville et al., 2012; Watson, 2001). It was therefore essential for this research to examine the influence of OL on LSS implementation within the Saudi Arabian context.

The participants in the sample were asked to rate the extent to which their organisations encouraged them to learn from each other's experiences, from errors incurred during project implementation, from failed LSS implementation projects or through any other sort of learning. The results shown in Figure 4.4, indicate that only one third of the organisations had definite OL practices in place to encourage learning. For the rest of the participants it was unclear whether an OL practice existed (2%), was reinforced (14%) or was clearly identified as an OL practice (51%), which suggests that even though the concept of learning might be taken on board, employees were not being encouraged to reflect upon the challenges faced to identify areas of opportunity and actions to prevent those challenges in the future.

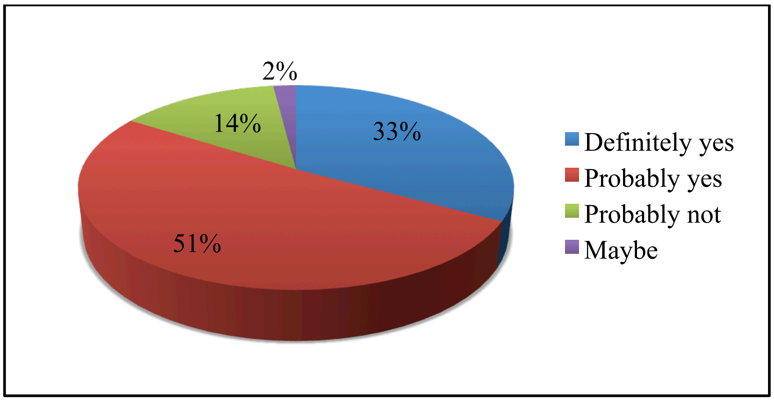


Figure 4.4: Lean Six Sigma Projects and organisational learning

4.2.3.10 Critical success factors (CSFs)

The CSFs used in this study were distilled from existing literature (Chapter 2). The CFSs identified by the participants for LSS implementation within Saudi Arabian organisations were found to be similar to the ones distilled from the literature, as shown in Table 4.8. Training and education, management commitment and support, communication, and project selection and prioritisation are the top-ranked CSFs.

Table 4.8: Comparison of the top five CSFs

Saudi Organisations	Literature
1. Training and education	1. Training and education
2. Top management commitment and involvement	2. Communication
3. Availability of resources	3. Top management commitment and involvement
4. Communication	4. Organisational culture
5. Project selection and prioritisation	5. Project selection and prioritisation

Other factors, such as organisational culture, linking LSS to an HR reward system and linking LSS to supply chain performance, were ranked lower in importance from a Saudi organisation's point of view. Perhaps the most contentious ranking was that of organisational culture, which did not feature in the responses as a CSF for LSS implementation within Saudi Arabian organisations, in spite of being in among the top five CSFs in the literature.

The involvement of other departments in the organisation, such as HR or IT, currently represents one of the greatest challenges in LSS deployment for Saudi organisations. The majority of the participants in the study believed that collaboration between the LSS team and other areas was difficult because it could take months to reach seamless collaboration. They reported that the same situation occurred when linking LSS to the supply chain, as this requires full participation and commitment from suppliers to spread LSS within their own business, and this can be difficult to accomplish.

4.2.3.11 Challenges for LSS implementation

The top challenges for LSS in Saudi organisations were predominantly centred on implementation times, leadership, and awareness of LSS benefits. Interestingly, less cited challenges were national regulations, unmanaged expectations and competing projects. These insights are slightly different to the findings in literature, as depicted in Table 4.9.

Table 4.9: Comparison of the top five challenges

Saudi organisations	Literature
1. Time-consuming	1. Unavailability of resources
2. Lack of leadership	2. Time-consuming
3. Lack of awareness of LSS benefits to the business	3. Internal resistance
4. Convincing top management	4. Lack of training or coaching
5. Internal resistance	5. Unmanaged expectations

Probably the most notable contrast between the findings from the literature and the results of this study is the impact of resources on successful LSS implementation. It appears that in Saudi Arabia financial resources are not an issue, nor do they create obstacles for LSS deployment. Some authors attribute this to the current situation of the country and the lack of economic crises over the past years (Drummond and Al-Anazi, 1997); others attribute it to the fact that organisations in Saudi Arabia do not pay taxes to run operations and people who live in Saudi Arabia and other Gulf Countries do not pay taxes for living expenses nor for public services, unlike Western countries (Taghawi-Nejad, 2015).

4.2.3.12 Tools and techniques of LSS

Integrating statistical and non-statistical tools and techniques within the Six Sigma methodology is recognised in the literature as one of the success factors for Six Sigma implementation (Antony and Desai, 2009). However, in opposition to the findings from literature on developed countries (Albliwi et al., 2015), the results of the survey in this study show that the top five tools and techniques used in Saudi organisations do not include any advanced statistical tools or techniques such as Statistical Process Control (SPC), Design of Experiments (DOE), Robust Design (RD). The most commonly applied were simple statistical tools and techniques, as shown in Table 4.10.

Table 4.10: Comparison of the top five tools and techniques

Saudi Organisations	Literature
1. Root-cause Analysis	1. Value stream mapping (VSM)
2. Brainstorming	2. Pareto analysis
3. SIPOC (Supplier-Input-Process-Output-Customer)	3. Cause and Effect analysis (C&E)
4. Process mapping	4. SIPOC (Supplier-Input-Process-Output-Customer)
5. Value stream mapping (VSM)	5. Design of Experiments (DOE)

These findings are aligned with previous research carried out in Saudi Arabia, concluding that, in comparison to their Western counterparts, Saudi organisations use only very traditional tools and techniques for Six Sigma projects, such as brainstorming and root-cause analysis (Alsmadi et al., 2012).

4.2.3.13 Impact of organisational culture on LSS

Organisational culture plays a very important role, as it can enable or inhibit the progress of any CI initiative (Valmohammadi and Roshanzamir, 2014). Moreover, change management and organisational resilience are very important to all CI initiatives and particularly for LSS success (Antony and Banuelas, 2002).

For the purpose of this study, the Likert scale was used to assess the participants' views on the impact of the organisational culture of their organisations on the successful implementation of LSS. Values were assigned as follows: 5= organisational culture has a strong positive impact on LSS and 1= organisational culture has a strong negative impact on LSS.

Most participants (65%) believed that their organisational culture was somewhat positive towards LSS, which translated into a positive attitude and support for its implementation, and 18% of participants considered their organisational culture as strongly positive for LSS implementation. At the other end of the spectrum, 12% of the participants considered that their organisational culture had a negative (5%) or somewhat negative (7%) impact on LSS implementation. Only 5% of the participants considered that the organisational culture did not have an effect on LSS implementation.

To substantiate their opinions, participants were asked to provide the reasons for their answers. The most recurrent issue reported by those who believed their organisations' culture had a negative impact was the "blame culture". Participants indicated that it was other peoples' mindsets against change that hindered the successful implementation of LSS. This was mainly due to the fact that changing traditional processes and coaching people in a new way of understanding processes and solving problems was seen as a difficult endeavour. Other recurrent issues were management changes, the lack of clear vision and the lack of understanding of LSS in 11% of the organisations.

In the cases where organisational culture was seen as a positive influence on LSS implementation, participants highlighted that it was a result of supportive CIOs, supportive IT, open discussion about processes, good communication, sharing information openly and teamwork. Some of the participants stated that the influence of Lean and Six Sigma was visible in changing the culture in their organisations and positively influencing the way people think about CI. Such sentiments support the hypothesis that, overall, Lean and Six Sigma can contribute to creating a positive organisational culture.

4.2.3.14 LSS project execution

The number of completed projects and their financial implications are recognised in the literature as some of the most important considerations in determining the success of LSS (Antony and Banuelas, 2002; Antony and Desai, 2009).

In order to obtain more details about project execution in the selected sample, the number of projects successfully completed, the number of failed projects and the perceived critical failure factors were investigated.

1- Number of projects completed successfully

All the participants in this study shared information about the number of successfully completed projects, as presented in Figure 4.5. The projects were considered to align with business goals and provided benefits to the organisation, where 22% had completed Six Sigma projects successfully (5% private and 17% public) and 13% of the organisations had completed Lean projects successfully (10% private and 3% public). However, 65% of the participants stated that their organisations had completed both Lean and Six Sigma projects successfully (49% private and 16% public), including those that embarked on Six Sigma first and then Lean or vice versa. Completed projects that failed to make a contribution to the organisation are discussed later in this chapter.

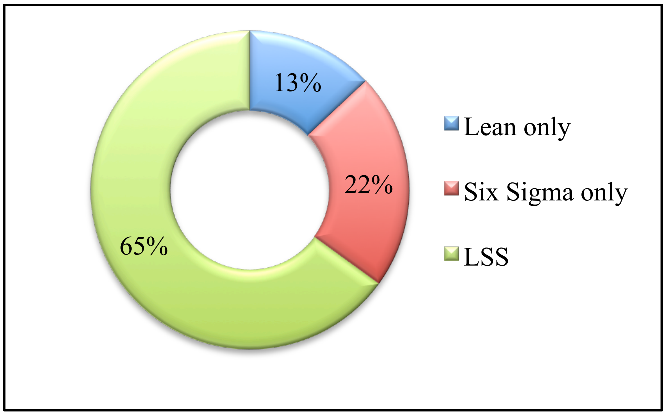


Figure 4.5: Percentage of organisations which had completed Lean and/or Six Sigma projects

The author observed that 8% of the respondents, including quality managers, LSS champions and MBBs had very little knowledge of the number of completed projects in their organisations. It would seem that these organisations were not recording data about the previous Lean and Six Sigma projects undertaken. Other reasons could be due to lack of communication between employees in the organisation. The remainder of the participants gave the average number of completed Lean and/ Six Sigma projects per year, as shown in Figure 4.6.

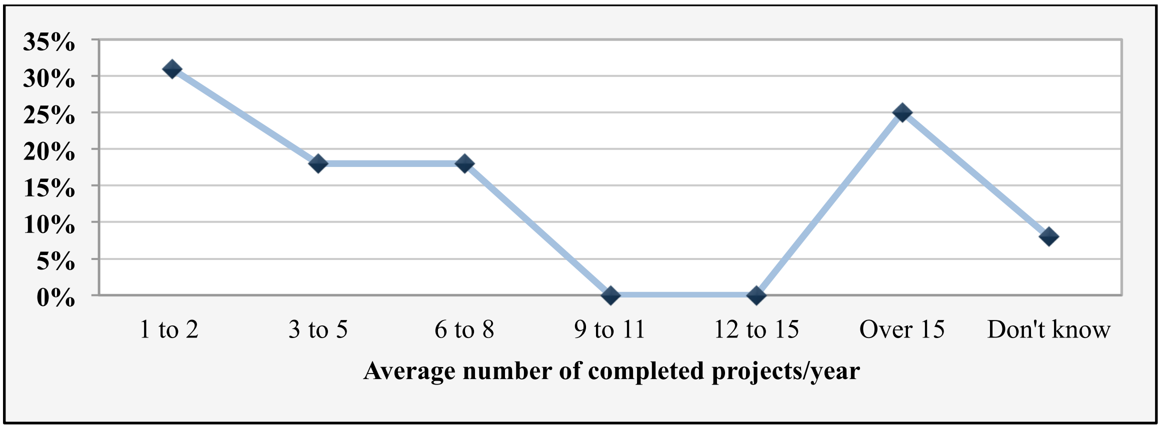


Figure 4.6: Average number of completed Lean and/ Six Sigma projects per year

The literature on the subject suggests that an optimum balance exists between the number of BBs and GBs within an organisation, in relation to the total number of employees, and the number of projects they should undertake (Harry, 1998; Voehl et al., 2013). For instance, an organisation with a count of a thousand employees should have 10 BBs and 50 GBs in their lines. Each BB should carry out two to three projects per year while each GB should complete two projects per year. Therefore, the ideal number of projects completed by 10 BBs would be a minimum of twenty per year, and for 50 GBs would be a hundred per year. This amounts to a total of 120 LSS projects every year for an organisation with 1000 employees.

If the same principles explained above are applied to the participating organisations, taking into consideration the time span in which they have actively pursued LSS, it is reasonable to conclude that the ratio of projects developed is below the optimum dictated by literature. The data show that the minimum number of completed projects equaled one project per year and the maximum 31 projects per year, with the exception of multinational organisations, which executed more than a hundred projects per year.

The information available on the financial investment and benefits from LSS projects also varied according to the type of organisation and the sector. In the case of the oil industry and the public sector organisations, information on the financial benefits was either confidential or had not been calculated, since the focus was on improving the quality of project selection and process efficiency rather than yielding financial benefits.

On the other hand, some organisations had clear figures on the projects undertaken, the investment required and the financial benefits achieved as a result of LSS. Two diametrically opposite examples are: organisation A, which completed around 300 LSS projects in eight years, with a total investment of between $15M and $20M for both Lean and Six Sigma, yielding around $150M in returned benefits, set against organisation B, which completed around 40 LSS projects in five years with a total investment of only $1M, yielding benefits in improved efficiency and quality of the internal processes.

It is important to highlight that a significant proportion of respondents, including quality managers, LSS champions and MBBs had limited knowledge of the number of completed projects in their organisation. It would appear that these organisations were not recording data about the previous Lean and Six Sigma undertakings, or perhaps the lack of awareness could be a result of poor communication within in the organisation.

2- *Number of failed projects*

All participants in the study were asked to share information about the failed Lean and Six Sigma projects in their organisations; however, only one third agreed to share information about those projects. A public university admitted to 15 unsuccessful LSS projects in five years of LSS implementation, while one of the oil organisations recorded 21 unsuccessful LSS projects in eight years of LSS implementation and an international construction organisation stated that only four LSS projects had failed in nine years.

Although every organisation that has implemented LSS is likely to have experienced failed projects, a third of the participants, of whom 22% were in public organisations and 10% in private organisations, indicated that they had not experienced any failed Lean and/or Six Sigma projects; the remainder of the participants indicated that they did not know the number of failed projects. It is argued in the literature that in some cases organisations are not willing to share details of their unsuccessful projects, for fear that this could affect their reputation in the market, leading to customer loss and a decrease in market share (Albliwi et al., 2014). The fact remains that this is a significant omission; the publication of detailed analysis of failed implementations or projects would be of great benefit to those businesses contemplating LSS implementation in the future (Albliwi et al., 2014).

3- Critical failure factors for LSS projects

According to Albliwi et al., (2014) there are many reasons that could cause LSS projects to fail. Investigating these reasons in Saudi Arabian organisations has resulted in some insights regarding the disparities and commonalities between the experiences from the organisations in the sample and the data presented in literature.

In the literature on this area some authors argue that around 70% of the organisations that have implemented LSS initiatives have failed to gain any benefits from their deployment, while others failed to achieve the expected results (Albliwi et al., 2014; Kumar et al., 2008a; Kumar et al., 2008b; Martinez-Jurado and Moyano-Fuentes, 2012). In the sample for this study, although only some organisations admitted to a number of failed projects, more importantly, some of these shared the reasons for project failure.

The main factors cited for project failure in these Saudi Arabian organisations spanned different areas but were mainly linked to a perception of poor leadership, the resistance to culture change, the lack of support and commitment from the management sphere, poor project management skills and lack of resources. The commonalities between failure factors in these Saudi Arabian organisations and those cited in the literature are presented in Table 4.11.

Table 4.11: Comparison of the top five critical failure factors for LSS projects

Saudi Organisations	Literature
1. Lack of visionary and supportive leadership	1. Lack of top management attitude, commitment and involvement
2. Resistance to culture change	2. Lack of training and education
3. Lack of top management commitment and involvement	3. Poor project selection and prioritisation
4. Poor project management	4. Lack of resources (financial,

5. Lack of resources (financial, technical, human, etc.)	technical, human, etc.) 5. Weak link between the CI projects and the strategic objectives of the organisation

From the participants' point of view, lack of leadership was the main reason for LSS project failure (62%), closely followed by resistance to culture change (56%) and lack of top management commitment (46%). Some authors argue that the perception of lack of leadership in Saudi Arabia is a consequence of the factors that impact leadership effectiveness. These include organisational culture, the traditional attitude of top management, lack of leadership development programmes (Al-Ahmadi, 2011) and centralised control, through the government, on public sector organisations (Alameen et al., 2015).

Even though, in many cases, the focus of LSS deployment was not linked to financial savings, the lack of resources was highlighted as an important challenge for successful LSS implementation. Saudi Arabian organisations in the public sector often attribute such difficulties to the bureaucratic complexity of the process to secure budgets to develop LSS projects. Thus, LSS projects are put on hold until the resources are approved by top level management or the pertinent government bodies. In addition, poor control over the financial resources available for LSS usually causes the organisation to lose a significant portion of the profit (Al-Ahmadi, 2011). In these cases, where supplementary financial resources are not easily accessible, it could be argued that the financial savings generated from LSS projects should be reinvested in additional LSS initiatives.

Notwithstanding the problems in securing resources for LSS deployment, one of the most quoted reasons for failed projects is related to people and the organisational culture they form part of. The literature argues that to better the implementation of LSS in Saudi organisations, it is important to select skilled personnel for senior management positions, preferably trained in project management, to ensure that project milestones are met (Antony and Banuelas, 2002). Yet, in developing countries, including Saudi Arabia, selecting people with the right skill set is very challenging, since the selection process is not designed to identify the most appropriate candidates in the candidate pool.

Overall, changing the organisational culture is essential for LSS success. This is in itself a challenging task, irrespective of the organisation's country of origin, size or operational acumen, because it requires time, resilience and willingness to change. Many world-class organisations spend years changing their organisational culture (Womack and Jones, 2005).

4.2.3.15 Financial benefits

The financial implications, both investment and savings, linked to LSS initiatives can be measured by the finance and accounting departments in the organisation. This is usually communicated to the key stakeholders and followed by a report sent regularly to all levels of management (Schroeder et al., 2008).

To determine the financial aspects of LSS in Saudi Arabian organisations the participants were asked questions about investment initiatives and return on investment.

1- Total investment in Lean and Six Sigma

The participants were asked about the total investment in the implemented initiatives to date. Most of the participants stated that they had no detailed knowledge of the investment on Lean and/ or Six Sigma in their organisations. However, it could be inferred from the participants' responses to previous questions that large organisations had allocated major budgets for CI initiatives in Saudi Arabia, reaching up to \$25M. Some examples of these inferences include: the investment since 2009 in LSS in a large public university would amount to \$1M; between \$15M and \$20M million had been invested in LSS by one of the leading oil producing organisations; and the participant from the tractor manufacturing organisation stated that the investment in Six Sigma and LSS to date was \$25M.

2- Ratio of investment to benefits and ROI

As stated earlier, the literature in the subject strongly recommends that financial benefits from LSS are measured to evaluate the success of a particular initiative. The literature suggests that the typical ratio of investment to benefits for Six Sigma is 1:3, meaning that for every \$1 invested in Six Sigma, there will be a \$3 profit (Bendell, 2006). However, for medium sized corporations, the expected ROI is around \$2 for every \$1 invested on LSS (Lawrence and Miller, 2015; Pulakanam, 2012).

The participants were asked about the ratio of investment to benefits from Lean and/or Six Sigma and the results are shown in Figure 4.7. More than half of the participants (55%) indicated that the investment to benefits ratio of in their organisations was 1:3 to 1:5. An additional 10% indicated that their organisations had an investment to benefits ratio between 1:6 and 1:8 and 5% of the participants, who worked in large multinational organisations, stated that the ratio was 1:9 to 1:10.

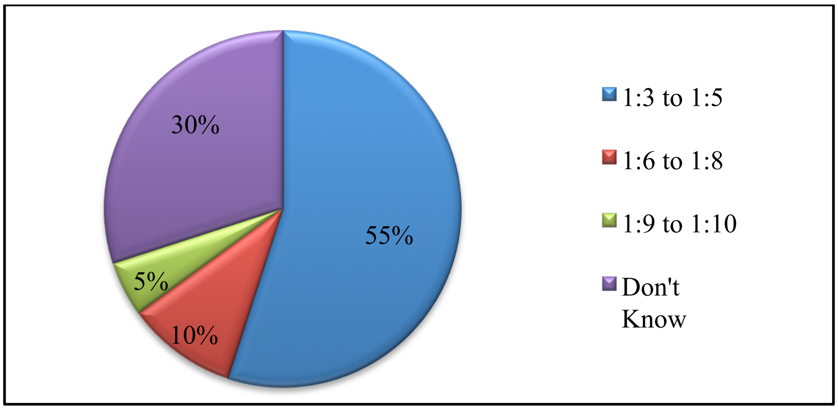


Figure 4.7: The Ratio of Investment to Benefits

From the sample of respondents, only 2 participants shared the exact figure of return on investment on LSS. The first of the two organisations that shared their figures had received \$150M ROI from the Lean and LSS initiatives implemented to that date and as the result of the \$15M investment over a 10-year period, which indicated that the ROI was 1:10. The other organisation had achieved \$80K ROI from the \$25K investment in Lean and Six Sigma projects over the past 4 years, indicating ROI of around 1:3.

Surprisingly, almost a third of the participants, which included quality managers and LSS practitioners, admitted to not having knowledge of these figures. The rest of the participants either refused to give detailed information related to ROI because of confidentiality concerns, stated that the organisation did not have the data, or suggested that they did not have that knowledge. This is evidence that there are several issues related to measuring benefits from CI initiatives in some Saudi Arabian organisations and that there are organisations that opt to ignore the financial impacts of LSS or CI initiatives. The latter finding is aligned with findings from previous studies in India, by Antony and Desai, (2009) where a third of the participants had no financial data to support the evaluation of the ratio of investment to benefits on LSS initiatives.

The possibility also exists that the participants in this research could have had concerns about information security and confidentiality, and therefore decided not to share details of their financial information.

4.3 Discussion of the survey findings

The results of the survey indicate that there are several aspects of LSS implementation in Saudi Arabian organisations that need to be addressed. In general terms, it was evident that there was a lack of awareness about the levels of implementation and success rates of LSS initiatives. This is particularly a point for consideration in this sample, given that most participants held LSS belts and were undertaking CI projects, and thus were expected to have knowledge of the past and present initiatives within their organisations. This lack of awareness is most likely a result of a poor communication and inefficient information-sharing practices within the organisation.

To gain more insights into the status of Lean and/or Six Sigma in these Saudi Arabian organisations, the results have been grouped according to the nature of the participating organisations.

1- International organisations

In this study, 13% of the participants were working in international organisations, all of whom refused to share financial information, including figures regarding investment and ROI. Participants from those organisations were well aware of the benefits LSS had brought to their business. LSS deployment was greater and better established in international than in local organisations, probably due to the influence on LSS implementation from their parent companies, in terms of history and learning. These organisations rated well in the success factors relating to the current status of their LSS initiatives, as, according to the participants, they had established levels of training and education, adequate numbers of LSS belts holders, healthy numbers of completed projects, high levels of LSS awareness, and an understanding of the value of organisational learning and open culture. However, the participants perceived that the main challenge faced in Saudi Arabia was changing organisational culture and changing peoples' mindsets.

2- Local organisations

Local organisations were by far the dominant group in the study. In this group some stand-alone organisations struggled more with LSS implementation than the organisations participating in joint ventures with leading multinational organisations such as Shell and Caterpillar. The main challenges faced by this group of organisations related to training, leadership, the application of the advanced tools and techniques, as a result of lack of awareness about LSS, and lack of top management support and commitment. In contrast, the private organisations with joint ventures were better prepared for LSS implementation, since their international counterparts provided training material, coaches, certification opportunities, support on process implementation, and other forms of support. These international organisations also sent a committee (consisting of LSS champions and practitioners) to check and evaluate the implementation process from time to time and request monthly update reports on the status of current LSS projects.

3- Public and Private organisations

Counter-intuitively, very few differences were observed between public and private organisations in terms of Lean and/or Six Sigma adoption. Respondents from both sectors reported similar challenges related to the levels of awareness of LSS, resistance to change and lack of leadership. Nevertheless, it appears that the private sector enforces CI improvement initiatives much more strongly than the public sector; which is evident in the data for aspects such as the number of years since the introduction of LSS, number of completed projects to date, number of people trained for LSS and the average times for project completion.

It is of value to shed the light on a particular example of a public organisation, a university that had successfully adopted LSS since its establishment five years previously. This university had around 230 GBs and 200 YBs and at least 350 members of staff had attended LSS awareness session. Even though, according to the literature, their number of BBs was still insufficient— only seven BBs when ideally there should be 20 BBs— the university had successfully carried out LSS projects in diverse business processes, including administration, finance, IT, procurement, and library management.

In general, and from the results above, it could be said the current status of LSS implementation in Saudi Arabian organisations is behind, when compared to that in Western organisations. Yet, it is clear that awareness regarding LSS is increasing in the country, although Saudi organisations will need years to gain the necessary knowledge, training and experience to achieve the same levels of successful implementation as those observed in the Western organisations.

4.4 Chapter summary

The purpose of this chapter was to assess the current status of Lean Six Sigma deployment in Saudi Arabian organisations, motivational factors and organisational learning practices. A survey was undertaken to collect data for Lean and Six Sigma implementation from different sources, such as practitioners, middle managers and CEOs, in organisations that had implemented Lean and / or Six Sigma for at least a year. The results show that there are still diverse of areas of improvement to be addressed before Saudi organisations can yield all the expected benefits from LSS implementation. As a starting point, more focus is needed in resolving the issues on training, customer needs, project selection and execution, investment, calculating the financial benefits, cultural changes, and effective leadership. Furthermore, improved communication between business units, employees and management, as well as integrating the Six Sigma team into all departments, would aid the understanding and implementation of LSS initiatives.

However, this research has certain limitations. It was constrained to Saudi Arabian organisations; thus, if these insights were to be used generically in other developing countries, validation of the conclusions presented in relation to such countries should be conducted, to ensure they are still well-founded in a different context.

Another limitation is that no deeper insights could be captured from the online survey alone. This limitation will be rectified in Chapters 5 and 6, through the findings of interviews conducted in selected organisations within Saudi Arabia.

The next two chapters aim to clarify some of the issues unraveled in this chapter, including the lack of measurement of financial benefits derived from LSS, the lack of training and the lack of completed projects; which were explored through semi-structured interviews conducted in five organisations in Saudi Arabia. The selection of these organisations was based on the following criteria:

- Data-rich organisations
- Organisations planning to improve and sustain Lean and Six Sigma
- Willingness to participate in the research
- Willingness to grant access to the organisation and allocate employees for interviews.

The targeted interviewees were CEOs, senior managers, quality managers, HR and finance personnel, and LSS team members, including Champions, MBBs, BBs and GBs.

CHAPTER FIVE

Within-Case Analysis

5.1 Introduction

The purpose of this chapter is to present the findings from five case studies undertaken in organisations in Saudi Arabia. It begins by presenting the background and demographic information for the case organisations (referred to as A, B, C, D and E), before addressing the characteristics that shape the current status of Lean Six Sigma in these organisations, such as infrastructure, level of training, benefits generated, commonly used tools and techniques, organisational culture and critical success factors. These characteristics have been combined into themes, which form the second unit of analysis. The findings from this chapter support the findings of the survey in Chapter 4 and contribute to answering the research questions set at the beginning of the thesis. The researcher has used both within-case and cross-case analyses, as suggested by Eisenhardt (1989a), Voss et al. (2002), and Yin (2003b).

5.2 Findings from semi-structured interviews

5.2.1 Organisations' background and demographic details

A summary of the case organisations' demographic details is presented in Table 5.1.

Table 5.1: Summary of organisations' background and demographic details

Elements	A	B	C	D	E
Business type	Heavy machinery and equipment distributor	Petrochemical manufacturing	University	Electrical manufacturing	Food, drugs and medical devices monitoring authority
Sector	Private – Local	Private – Local	Public – Local	Private – Multinational	Public – Local
Base	Saudi Arabia with American joint venture	Saudi Arabia with American joint venture	Saudi Arabia	French parent	Saudi Arabia
Annual turnover	Over $50m	Over $50m	None	Over $50m	None
Number of employees	2000	900	4500	1200	2000
Location	Kingdom- wide	Eastern coast of Saudi Arabia	Eastern coast of Saudi Arabia	Central part of Saudi Arabia	Central part of Saudi Arabia
Main products/ services	Tractors, material handling equipment, industrial	Ethylene, Crude Industrial Ethanol, Styrene,	Undergraduate teaching and postgraduate teaching and research	Switchgear boards, small panels, small sockets etc.	Monitoring of food and drug safety and effectiveness for humans and

	hammers, trucks, specialised lifts, cranes etc.	Caustic Soda, Ethylene Dichloride etc.			animals, bio-pharmaceuticals etc.
Main customers	The government, construction and infrastructure organisations, logistics, warehousing etc.	Shell and other customers in Asia-Pacific region	Students, academic staff, alumni and industry	The government, contractors, electricity companies etc.	Public and private hospitals, labs, factories, warehouses and importers of food, drugs, pesticides etc.

The table shows that the participating organisations were large organisations undertaking different types of business in service and manufacturing, including both private (3 organisations with annual turnover of over $50m) and public (two organisations) sectors. The organisations were located in different parts of Saudi Arabia which allowed the researcher to collect data from different environments. Each organisation had different products/services and different customers, including the government, and some organisations had both local and international customers. More details about each organisation are presented throughout this chapter.

5.2.2 History of quality practices in the case organisations

Table 5.2 summarises the history of quality practice in the case organisations, including any quality awards received.

Table 5.2: Summary of quality practices in the case organisations

Quality practices	A	B	C	D	E
ISO	ISO 9001since 1996 ISO 14001in 2013 OHSAS 18001in 2013	ISO 9001since 1990s ISO 14001in 2015 OHSAS 18001 in 2015	ISO 9001 in some departments in 2012 ISO22000 in 2013	ISO 9001 in 2005 ISO 14001in 2007 OHSAS 18001in 2014 ISO 50001in 2014	Only one department received ISO 9001in 2012
TQM	Started in early 1990s across the organisation but then replaced by Six Sigma in 2003	Started in early 1990s across the organisation but then replaced by Six Sigma in 2005	In 1996 in the teaching hospital but then replaced by Six Sigma in 2013	In the past before Six Sigma (in the 1990s)	Never implemented
Lean	2010 to present	2012 to present	Never	2004 to	Never

	(in conjunction with Six Sigma)		implemented	present	implemented
Six Sigma	2003 to present	2005-2008 and training started again in 2015	2013 to present but still in the early stages	2005-2008 and again in 2015	Never implemented
LSS	2010 to present	In the future	In the future	2015 to present	2013 to present
Quality awards	None	None	None	None	None
Existing quality practice	Lean, Six Sigma and the organisation's own production system	Lean	Six Sigma	Lean, Six Sigma and the organisation's own production system	1 Lean Six Sigma pilot project

From Table 5.2, it can be seen that organisation A introduced Six Sigma first, in 2003, before they even introduced Lean and organisation B had a similar history, with Six Sigma used since 2005. These organisations adopted Six Sigma first due to the American influence from their joint venture organisations. The implementation of TQM in organisation B facilitated their ISO accreditation, and both ISO and TQM were platforms for Lean at the time of the case study and for Six Sigma in the past, in 2005. Although organisation B was implementing Lean at the time of the research, the organisation had sent employees for LSS training. Organisation C had not adopted Lean officially but Lean tools were used in some Six Sigma projects and the organisation had a plan to deploy Lean officially in the near future. These organisations were not fully embracing LSS but they were using CI methodologies such as Lean or Six Sigma and they were planning to integrate these methodologies in the near future (based on the interviews and interventions with these organisations). Organisation E had no CI practices until 2013. However, organisation E had adopted LSS as a pilot programme in 2013, which means it is classified as a late adopter. More details about the quality practices in each organisation are presented throughout this chapter.

5.3 Current status of Lean Six Sigma in the case organisations

The current status of LSS in the case organisations was assessed in terms of the key characteristics identified in the literature (see Chapter 2), which were grouped thematically. Figure 5.1 shows how the themes were formulated and their primary objectives.

Theme	**Objectives** *To understand*:
1. Awareness, infrastructure and training for LSS	-Years of experience in LSS and CI -Number of people trained for LSS -Requirements for LSS training and certification -Roles of LSS team members -Extent of organisation's and employees' awareness of benefits of LSS to the business
2. Methodologies, tools and techniques of LSS	-The most and least frequently used tools and techniques -Criteria for selecting tools and techniques
3. Benefits generated from LSS and the impact of LSS on business functions	-The benefits generated from LSS -The impact of LSS on business functions -Number of business functions deploying LSS -Measuring LSS success in the organisation -Investment in LSS and ROI from LSS
4. Critical success factors (CSFs) for LSS	- The most common CSFs for LSS
5. Challenges for LSS implementation	- The most common challenges encountered by LSS teams during the implementation process
6. Impact of organisational culture and leadership on LSS	-The negative/ positive effect of organisational culture on LSS deployment -The role of leadership in LSS deployment and changing the organisational culture
7. LSS projects	-The number of projects implemented successfully -Number of failed projects -Reasons for failure -Criteria for project selection and prioritisation -Methodologies used for LSS project execution
8. Role of IT and HR in LSS	-How other business functions are involved in LSS deployment such as IT and HR

Figure 5.1: Key themes and objectives of LSS research in case organisations

5.3.1 Awareness, infrastructure and training for LSS

Organisation A had been deploying Six Sigma for 12 years and Lean for five years (at the time of the interviews). The initiative was being supported by the main supplier of Organisation A, which is located in the USA (Caterpillar). The organisation started its LSS journey with a Big Bang approach, training between 10 and 15 full-time Black Belts (BBs) to work on dedicated projects. At the time of the interviews, it had 13 LSS teams, who decided which problems required the implementation of LSS methodology. The organisation had one deployment champion, one MBB and around 100 BBs. More than 400 GBs had been trained over the previous 12 years. Many BBs had returned to their normal operational roles and responsibilities after their training, while some moved to other organisations. To avoid wasting money, these BBs were asked to pay back their training costs before leaving.

As the primary supplier of Organisation A was a US-based company, the deployment strategy, training curriculum and criteria for certification followed US standards.

The LSS training and belt system within Organisation A was implemented as follows:

1- Yellow Belt training: this involved a one-day introduction to LSS, with no exam or project required to become certified. Every individual in the organisation had been trained for Yellow Belt (YB) by the MBB. As a result, there was a much higher level of awareness of LSS in Organisation A than in the other case organisations. Certified YBs were able go on to GB training.

2- Green Belt training: trainees were obliged to attend a two-day course covering the fundamentals of Six Sigma DMAIC methodology, which they had to apply to a current problem within the organisation. There was an examination at the end of the training. Trainees were selected for GB training on the basis of the problems facing the company. With help from the champion, the project owner selected people working in the problem area, who were then trained internally by a BB (with guidance from the MBB as required) to help them find the solution. (It should be noted that Organisation A's pattern of putting BBs in charge of GB training and the MBB in charge of YB training is not recommended in the literature.) After certification, GBs would carry out simple projects when required, using basic tools (mostly from the Lean toolbox). GB projects generally lasted four to six months.

3- Black Belt training: Customised BB training was being delivered externally by Caterpillar, with whom organisation A was in a joint venture. Trainees were required to pass an exam and successfully complete a project to be certified. After certification, BBs had to implement two BB projects per year each project, taking around six months, but there was no specific saving target for the two projects.

   The selection of BBs for training was based on performance: individuals were selected based on characteristics such as being flexible in how they worked, having the relevant experience, being analytically minded, and having the passion to deliver projects. The organisation set out to put LSS BBs in all its key domains, with the result that it had more than 100 trained BBs, at the time of the interview.

4- Master Black Belt training: this comprised four weeks' training in a combination of Six Sigma and the organisation's own production system, with the candidate being required to select and complete four LSS BB projects within two years. The MBB was responsible for delivering BB, GB and YB training internally, using Caterpillar's curriculum and exams. This included guiding BBs through their projects, selecting people for BB training, delivering training for GBs and acting as the contact for the LSS deployment champion and other project champions in the business.

5- Champion: this could only be offered to an MBB with years of experience in LSS project execution, who had a management role and team management skills. His responsibilities included ensuring alignment of LSS projects with the organisation's goals, which involved understanding the priorities of the business and translating them into strategic or operational LSS projects. The champion was also responsible for developing the business case for LSS projects, developing a LSS project charter, removing roadblocks to projects being carried out by BBs or GBs and conducting toll gate reviews. Organisation A had only one deployment champion, who trained as a GB in 2003; he became a BB in 2005, before being promoted to MBB in 2007. At the time of the study, he was in charge of the department with responsibility for overall LSS deployment within the group.

Organisation B introduced the Lean initiative in 2012, with the support of one of the general managers, who was at the time of the interview the Lean deployment champion, with the main responsibility for selecting projects and trainees, coaching and guiding the team, dealing with challenges and monitoring project progress. He was also responsible for raising awareness of Lean across the business and for making Lean the primary catalyst for Continuous Improvement. The organisation applied a very strict policy of selecting people for Lean training based on their performance and creativity. To the date of the study, only 32 employees had completed the training; these included five executive managers and at least three people from each department (i.e. maintenance, finance, training and engineering).

Organisation B offered two levels of Lean training to employees: external and internal. The external training comprised a two-day course delivered by a European consulting firm based in Saudi Arabia. Certification as a Lean practitioner required the completion of a Lean project which called for the use of the Lean tools taught during the training. The internal training was informal and involved three days working alongside a Lean team manager on a project to improve or implement new business processes in the company.

Organisation B deployed Six Sigma between 2005 and 2008 and then restarted Six Sigma again in 2015 (see Table 5.2). Up to the time of the research, two people had completed the Six Sigma training delivered by the same consulting firm from Europe, though no one had yet been certified. The consulting firm offered a three-day LSS Yellow Belt course and a three-week (120 hours) LSS Black Belt course. Both YB and BB certification demanded the completion of successful projects: for BB certification trainees were required to complete two projects with a combined minimum of $1 million savings to the bottom-line of the business, while for YB certification, trainees were required to complete one project, with no target for specific total savings.
Although awareness of Lean and Six Sigma was growing in Organisation B, this awareness depended largely on individuals' previous work experience, position and training. Moreover, employees were not fully engaged with these initiatives, because of the mixed results its implementation had produced so far.

Organisation C had been implementing Six Sigma for two years and had a plan to introduce Lean (at the time of the interviews); like Organisation B, it was still building a CI infrastructure. At the time of the interviews, the university's main focus was on achieving academic accreditation[3] (since achieved, in 2015), but its next intended steps were to raise quality and speed up the implementation of Six Sigma. Although it had four Six Sigma BBs working in the quality assurance department, these staff had no ongoing Six Sigma projects, as they were all fully occupied with the accreditation process. This, in turn, led to a very low level of Six Sigma awareness, compared to the other case organisations. Organisation C had no LSS deployment champion and only one Six Sigma GB. The four Six Sigma BBs and one GB were all trained abroad prior to joining the organisation. The role of BBs in the university was still being decided, but it was likely to include responsibility for raising awareness of Six Sigma across the university and conducting Six Sigma projects in different functions.

Organisation D had been implementing Lean since 2004, as part of the organisation's own production system, which also incorporated ISO standards. Six Sigma was deployed between 2005 and 2008 and redeployed again in 2015. Its LSS infrastructure consisted of a LSS champion (plant VP for the past two years and with experience of working with LSS in the

[3] The National Commission for Academic Accreditation and Assessment (NCAAA) determines the standards and criteria for accrediting higher education institutions and the programmes they offer.

company's Danish site), 14 GBs, one MBB and four BBs. None of the BBs was full-time, instead conducting LSS projects on top of their normal duties. The first wave of GB training was delivered to 20 employees by a USA training company in 2005. Five of these employees were then chosen for BB training, which comprised 10 days full-time training followed by a project and accompanying presentation.

At the time of the interviews, the organisation's Six Sigma YB, GB and BB training material was available on its intranet for any employee to study in his/her free time. The GB online training was 29 hours long and included eight modules, each with an exam. This was followed by a project, which the trainee was then required to present in one of the parent organisation's international sites before sitting another exam. Once certified, the GB was required to implement three Six Sigma projects which would collectively achieve a minimum 10% increase in productivity each year. The BB training was shorter and less demanding, focusing on management skills, project execution and teaching LSS. Finally, the organisation offered 'Lean expert' training. This lasted three weeks, covering all the Lean tools and techniques. The course was devised internally by the organisation's own consultants.

Since no-one was working on Lean and Six Sigma projects full-time in Organisation D, the roles and responsibilities of the CI team were not clearly delineated. Projects, which were generally small in scope, were initiated in response to specific problems, with the champion providing guidelines when required. Awareness of LSS and Lean in particular had increased sharply in the previous two years, in response to instructions from the organisation's French parent company to take CI seriously and to send more people for training.

Organisation E initiated its first LSS project in 2013, to improve processes in its medical devices department. The project was implemented by a team made up of four people from the department, along with three employees from the quality department and an external facilitator.

This organisation had a very small LSS team, comprising one MBB, two BBs and three GBs. There was no champion. None of the BBs were working full-time on LSS projects, nor were they required to conduct a specific number of projects or achieve a specified level of savings. Projects were initiated as problems occurred, and the roles and responsibilities of the LSS team had not yet been clarified. The LSS team members were all trained in the UK, but by two different training institutes, whose certification requirements differed.

Because of the pilot project, there was a high level of awareness of LSS in the quality and medical devices departments, but other departments, and even some managers, had no awareness of LSS. To address this, the LSS team developed Lean awareness classes and online videos presenting the essentials of Lean. The classes, which were delivered to employees by the MBB, each started with a video lasting 15 minutes. The classes were followed by an exam to become certified in Lean awareness.

Although Lean and Six Sigma have been deployed in Western organisations for more than two decades, the above findings indicate that their implementation in Saudi organisations is very recent. Organisation A had been implementing LSS the longest (12 years), while Organisation E had only very recently begun to show an interest in CI practices. Table 5.3 summarises the LSS belt system and requirements for certification in these organisations, excluding overseas training requirements.

Table 5.3: Lean Six Sigma training in the case organisations

<table>
<tr><th>Training</th><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th></tr>
<tr><td>YB</td><td>1-day training
No project or exam required</td><td>3 days + 1 project</td><td rowspan="5">Employees trained abroad in USA and India</td><td>15 hours online training + exam</td><td rowspan="5">Employees trained abroad in UK and USA</td></tr>
<tr><td>GB</td><td>2 days on project training+ exam</td><td>NA</td><td>29 hours online training + 1 project and 2 exams</td></tr>
<tr><td>BB</td><td>4 weeks + project and exam</td><td>3 weeks + 2 projects with $1 million total saving</td><td>10 days + 1 project and presentation</td></tr>
<tr><td>MBB</td><td>4 weeks training + 4 projects within 2 years</td><td>NA</td><td>No training required</td></tr>
<tr><td>Champion</td><td>No training required</td><td>NA</td><td>No training required</td></tr>
<tr><td>Lean training</td><td>NA</td><td>Internal: 3 days + work-based assignment
Or
External: 2 days + project</td><td>NA</td><td>3 weeks</td><td>15 minutes’ introduction + exam</td></tr>
</table>

It is clear from Table 5.3 that there were no standards for Lean and LSS training in the case organisations. The type of training was different, depending on the different providers. It was also observed that some organisations, e.g. organisation B, had no available training programme for GB, MBB and champion. The length of Lean training also differed from one organisation to another, e.g. organisation B had a 2 to 3-day training programme, organisation D had a 3-week programme, while organisation E had prepared a 15-minute video introduction to Lean, which is uncommon in Western countries. Table 5.4 summarises the LSS infrastructure in the case organisations and gives more insight into the current LSS infrastructure.

Table 5.4: LSS infrastructure in the case organisations

LSS infrastructure	A	B	C	D	E
Number of YBs	All employees	None (1 trained but not certified yet and 20 were still in training)	None (Plan to train 25 employees)	20	None (Plan to train 30 employees)
Number of GBs	400	None (1 employee in training)	1	14	3
Number of BBs	100+	1	4	4	2
Number of MBBs	1	None	None	1	1
Number of champions	1 LSS champion	1 Lean champion	None	1 LSS champion	None
Training provider	1- Training abroad for BBs sponsored by the organisation 2- In house training for GBs by BBs and MBB	Lean practitioners trained by external training institute	All BBs trained before they joined the university	1-In house training for Lean and leadership 2-Online training for Six Sigma	All BBs trained before they joined the organisation
Availability of quality department in the organisation	Available and responsible for quality standards but not responsible for LSS	Available but not responsible for Lean	Available – at the heart of the LSS initiative	Available but only responsible for quality assurance and method engineering	Departmental quality teams replaced by centralised quality department responsible for LSS
Level of awareness of Lean/Six Sigma	Everyone aware of LSS including owners and CEOs	Everybody aware of Lean including the CEO, very limited Six Sigma awareness	Very low LSS awareness in general but quality department was fully aware of LSS	Awareness of LSS across the organisation was increasing since the arrival of the new VP	Awareness of LSS was increasing with more training arranged

Table 5.4 shows that there is no consistency across the case organisations for infrastructure, awareness or training. Each organisation was ‘doing it its own way’. It is clear that the two public organisations (C and E) had the weakest infrastructure, with few people trained as GBs and BBs, and no deployment champion available. However, both said they had plans in place to train a group of employees as LSS YBs. It was found that in the private organisations the quality department was not responsible for LSS, while in public organisations LSS and CI

were the major responsibility of the quality department. These aspects are discussed in Chapter 8.

5.3.2 Methodologies, tools and techniques of LSS

In Organisation A, DMAIC was the main methodology for all LSS projects conducted so far. This was supplemented by the organisation's own production system, which was designed to help the organisation eliminate seven types of waste in its process, find solutions quickly and complete projects promptly. While the organisation's own system was a short-term project, the use of DMAIC was a long-term project. DMEDI (Define, Measure, Explore, Develop, Implement) was also occasionally used to introduce a new product to the market (DFSS).

The most commonly used tools and techniques were simple ones, such as SIPOC, process mapping, VSM, FMEA, progression charts, cause and effect analysis, root-cause analysis and hypothesis tests. Only 25% of the LSS toolbox was being used – which involved the simple tools. The least commonly used tools were complex statistical techniques such as DOE and SPC, functional department mapping (FDM), ANOVA, chi-square and regression analysis. The choice of technique depended on the nature of the project, but the team tended to take the view that 'simpler is better' and to avoid anything that was unfamiliar. The BB had the job of selecting the most appropriate tools and presenting them in the kick-off meeting for signing off by the MBB.

Organisation B used the DMAIC methodology when it first introduced Six Sigma, in 2005, but at the time of the research, B was using the Lean five-stage methodology which starts off with understanding the customer and their requirements and proceeds to mapping the value stream, and finally to achieving a pull system. In order to go through this cycle, the organisation used PDCA, which helps in building CI.

The team's choice of tool was dependent on the nature of the project, but it usually opted for standard tools from the Lean toolbox so that people could become familiar with them. These included 5 Whys/ root-cause analysis, FMEA, SIPOC, VSM, function flows, A3, process flow, cause and effect analysis, cost benefit analysis, visual management, the KPIs health check or a Gemba walk. Other tools could be selected if required by the project, although the available data tended to be too weak to allow statistically advanced tools to be used at anything more than a very basic level.

Organisation C employed PDCA or DMAIC, depending on the nature of the project, with at least three or four tools/techniques being selected from the chosen methodology. The most frequently used tools/techniques were SPC, control charts, Poka-Yoke, root-cause analysis/5 Whys, SIPOC and process capability analysis, while the least commonly used were multivariant analysis, tree diagrams, 5S, DOE, ANOVA and MANOVA. The selection of tools/techniques depended upon the objectives and requirements of the project; the interviewees reported that, so far, there had been little need to employ Lean tools.

Organisation D used DMAIC for all its Six Sigma projects in the past, but this was currently only used in a very limited way, for production line projects. The second methodology was the organisation's own production system, although the nature of the country and the mindset of the customers' meant this was not always the most suitable choice. The last methodology was DMADOV, which was used very rarely to design new products.
The core tool/technique for all projects was VSM/flowchart, supplemented by 5S, FMEA, process mapping, cause and effect analysis, root-cause analysis/5 Whys, Kaizen, project charters, brainstorming, Jidoka, poka-yoke, Pareto analysis and regression analysis. Advanced statistical tools/techniques such as SPC and DOE were not used, because they are only suitable for production lines (according to one GB). The organisation was more familiar with Lean tools than Six Sigma tools because they are simple and do not require a statistical background. Tools/techniques were selected according to the nature of the problem, with BBs relying on their own experience to ensure that the right tools were chosen.

Organisation E used DMAIC as the main methodology for its LSS pilot project because it offered a sophisticated framework for organising the implementation process. Tools and techniques used under DMAIC included SIPOC, cause and effect analysis, root-cause analysis/5 Whys, project charter, flowcharts, histograms, KPIs, run charts, Pareto analysis, affinity diagrams, interrelation diagrams (between parts) and ANOVA. Tools were selected based on the project's nature, but the quality team wanted them to be simple, as they lacked experience. The kick-off meeting included a brainstorming session to agree on tools with the process owner.

5.3.3 Benefits generated from LSS and the impact of LSS on business functions

The participants were asked to report the benefits (both soft and financial) generated from LSS in their organisations and the impact of LSS on business functions, as shown in Table

5.5. To measure the financial benefits, it was necessary to ascertain how much had been invested in initiatives to date and how each organisation measured the financial benefits to the bottom-line.

Organisation A was deploying LSS in most of its departments, including HR, sales, finance, IT, operations, heavy machines, customer service, rental and used equipment. Each of these departments had executed at least one LSS project to solve a problem and obtained both soft and hard benefits as a result.

Soft benefits from LSS included the organisation becoming more process-oriented, raising process efficiency and improving employees' skills. There had also been a perceived change in the mindset of employees, who now exhibited better morale and an enhanced sense of ownership. Collectively, this had led to improved satisfaction among both internal and external customers. Among the hard benefits, the top benefit was the reduction in waste, followed by greater time efficiency and improved data accuracy, quality and reliability. Jobs had become more standardised, employees were more familiar with processes, and more efficient ways of handling the business had been identified.

The organisation's investment in LSS had mostly been to support the infrastructure, so varied from year to year according to how many staff had been trained. However, the estimated total investment in Lean and Six Sigma to the time of this study was around $25 million. There was a system for tracing the ROI from LSS projects, but the LSS champion refused to share the figures, citing data confidentiality.

LSS success was measured through financial saving (if the project was related to the finance department) and the successful delivery of projects and improvements in efficiency; a database and dashboard showed what stage each project was at and the benefits it had brought, whether this was financial income or process improvement. Customer satisfaction, meanwhile, was measured via face-to-face meetings with internal customers. The voice of external customers was captured via feedback from the customer service department and a telephone-based customer satisfaction survey (developed with help from Caterpillar).

Organisation B had deployed Lean across the organisation, but it was most frequently implemented in the maintenance and engineering departments and operation, where it covered 75% of business processes. The reported benefits included the elimination of waste, better organised and more efficient processes, higher-quality output, and better engagement between leaders and the Lean team: the participants explained that the leaders were now not in their offices but on the shop floor and, because they were part of the change, they were familiar with and understood the processes. They expressed the view that Lean has also allowed the organisation to plan for sustainability.

The organisation was spending around $2 million per year on consultants to train employees to use Lean tools and techniques, and on the salaries of individuals hired for Lean implementation. This amount came from the profits. As the organisation was still at the beginning of its Lean journey, it had not yet measured ROI, although this was in the plan. Instead, Lean success was currently being measured in terms of the savings arising from improved process efficiency, lead-time, safety and reliability, using KPIs. The participants reported that the organisation did not link Lean directly with cost at this stage, because this was not the prime aim; rather, the aim was continuous improvement. However, it was planned that the next stage would be more focused on financial benefits.

The most important customers for Organisation B were internal, such as the operations, maintenance, technical, HR and finance departments. However, at the time of the study, there was no tangible measurement for internal customer satisfaction, apart from a satisfaction survey which was distributed to all employees every year (with action being taken based on the survey results). This survey was required by the CEO of the group and he examined the results personally. The purpose of the survey was to measure employees' satisfaction in terms of aspects such as their responsibilities, work environment, promotions, commitment and loyalty.

External customer satisfaction was the responsibility of head office, as Organisation B had no direct dealings with external customers.

In Organisation C, Six Sigma operated only in the university's teaching hospital (with some Lean tools), where it had helped to reduce waste and generated savings. According to the participants, in one year it had reduced patient risk by almost 26%, enhancing patient safety and increasing patient satisfaction, while the introduction of risk reduction training had also improved employee knowledge in this area. However, it had yielded no monetary benefits, as the hospital is a public hospital offering free treatment. Nor was it possible to calculate the amount invested in Six Sigma alone, because this money formed part of the general budget allocated for quality. As is usual in public organisations, ROI had never been calculated.

Instead, Six Sigma successes were measured through KPIs, such as the rate of waste reduction in the process, customer satisfaction and patient safety. The main method of measuring external customers' (i.e. patients') satisfaction was the patient satisfaction survey, which aimed to improve the services provided for patients in the clinics and the hospital.

In Organisation D, Lean methodology was dominant, supported by and part of the organisation's own production system, and thus could be seen in all departments. According to the interviewees, the organisation had seen massive savings since changing to Lean. In 2015, savings jumped from $80,000 to $1 million when production lead-time was reduced from 140 hours to 80 hours. This resulted in cost savings and fewer process defects, as controlling the process had become easier. Customer satisfaction also improved, despite the fact that the organisation has very demanding customers.

The company was unable to say how much it had invested in Lean, Six Sigma and other CI initiatives because there was no dedicated CI budget. Nor was it possible to isolate the financial benefits from Lean and Six Sigma, as the finance department's annual calculation of ROI and financial benefits was for all the organisation's projects, not just those under Lean and Six Sigma.

Success was measured in terms of financial growth from year to year (e.g. in 2014, growth increased by 18% compared to 2013) and improved results and savings. These were measured using KPIs such as productivity, production lead-time and efficiency, while customer satisfaction was measured through customer feedback. This was the responsibility of the customer satisfaction engineer in the after-sales department.

Organisation E had executed one LSS BB project in its medical devices department. The respondents reported that this project had brought many benefits to the organisation: process and employee efficiency had improved, service lead-time had been reduced (e.g. the time for issuing a medical devices certificate was reduced from 35 days to 12 days) and NVA activities had been eliminated.

The organisation had invested in quality in general, educating employees in quality tools and techniques across the organisation, but there was no dedicated funding for LSS. ROI and financial savings were not priorities and were never calculated, as the main focus of the LSS project was to improve processes and efficiency. Indeed, as a public sector organisation, there was no measure for calculating savings. LSS success had therefore been assessed not in terms of money saved, but by raised productivity, improved quality and increased customer satisfaction (though the last was still to be measured).

Table 5.5: Business functions using LSS and the most common benefits generated from LSS

	A	B	C	D	E
Business functions using Lean/Six Sigma	Most of the departments	All departments	Teaching hospital only	Most of the departments	Medical devices department only
Benefits of implementing Lean/Six Sigma	1-Reduced waste in the process 2-Had become a process-oriented organisation 3-Improved process efficiency 4-Changing employees' mindset 5-Increased customer satisfaction	1-Reduced 7 types of waste in the process 2-Improved process efficiency and effectiveness 3-Improved output quality 4-Created engagement between management and employees 5-Allowed restructuring of processes to ensure sustainability	1-Reduced waste in the process 2-Increased customer satisfaction 3-Reduced patient risk 4-Increased patient safety 5-Raised employee awareness of CI practices	1-Increased financial benefits 2-Increased customer satisfaction 3-Reduced production time 4-Fewer defects 5-Increased control of the process	1-Improved process efficiency 2-Reduced servicing lead-time 3-Eliminated NVA activities 4-Employees completed daily tasks more efficiently
Measures of project success	Based on financial and non-financial benefits, e.g. quality and process efficiency	Based on KPIs, e.g. process efficiency, lead-time reduction, safety and reliability	Based on KPIs, e.g. the rate of waste reduction, customer satisfaction, increase in patient safety	By comparing financial growth from year to year, productivity, production lead-time and efficiency	Based on perceived improvement in the process and increases in work efficiency and customer satisfaction
Investment in Lean/Six Sigma	Total of around $25 million	$2 million a year	No figure	No figure	No figure
Measure of financial benefits (ROI)	ROI (confidential)	Measuring ROI is in the plan (not measured yet)	None (public sector)	ROI measured annually (confidential)	None (public sector)

The table above shows that LSS was deployed in the private organisations A and D in most of the departments, while B was deploying Lean across the organisation. The two public sector organisations were deploying Six Sigma and LSS in only one department, with future plans for more LSS projects across the organisations. It was observed that soft benefits were more common than financial benefits, although most of the participating organisations refused to share any figures about investment and ROI. These aspects are criticised in Chapter 8.

5.3.4 Critical success factors (CSFs) for LSS

Organisation A considered top management support and involvement as the top CSF for LSS. The top management, including the CEO (who was one of the owners) were very supportive of LSS in the organisation, while the owners were well-educated about LSS – some had even been trained as BBs and were able to participate in the project selection and review process. The organisation's efforts to systematically train, mentor and coach all employees, and its use of effective training materials, enabled it to maximise the chances that projects would be successful; in other words, its willingness to make the necessary resources, human, financial and material, readily available was another major CSF. Also important was its selection of value adding projects which had meaning, focus and definition, and its ability to close projects on time (no project had taken more than a year) and to set achievable goals. The ability of senior managers to communicate what they expected from BBs and MBBs, and the selection of the right (i.e. highly motivated and adaptable) staff for training and project participation were identified as the remaining critical factors.

Organisation B saw strong leadership as the most important factor for Lean success. Keen to see the initiative succeed, the organisation's leaders were supporting Lean practitioners to change the organisational culture. Although only 32 people had been trained at the time of this research, internal and external Lean training was seen as another CSF, while choosing the right individuals to become champions and change agents was also seen as critical. Emphasis was placed on the importance of training programmes focusing on leadership and culture. Another CSF was having a top management system that clearly defined roles and responsibilities and provided visual mechanisms for controlling performance metrics; this system was seen by the participants as encouraging more consistent output, improved quality and greater efficiency. The company's ability to select the right value-adding projects was identified as another CSF, as was ensuring that employees had enough time to work on these projects, and the availability of skilled and experienced Lean practitioners (highlighting the importance of knowledge transfer from similar organisations in other countries). The last CSF identified was selecting the brightest people for Lean projects and training (although these were usually the busiest employees).

Participants from Organisation C stated that the top CSF for Six Sigma is the support and involvement of upper management, with the second being the availability of data (the university had collected a massive amount of data as part of its accreditation process) as this can speed up the time taken to complete projects. The third CSF identified by participants from Organisation C was its recruitment of two new BBs who were qualified and highly experienced in Six Sigma, while the fourth was being able to change people's mindsets and existing way of working. The final factor identified was the quality of training; even a limited number of well trained staff can effect change and raise awareness of Six Sigma throughout the university.

Organisation D identified training as the top success factor because of the central importance of staff having the right skills, although it was emphasised that involvement in Lean training and projects should be voluntary (rather than enforced by managers). The importance of staff motivation and willingness was highlighted: the organisation had made its LSS training available online so that any employee who wanted to could access it. Another highlighted CSF was having skilled and experienced leaders to support and guide the implementation process. The availability of a communication board to share information between employees and managers, such as the daily email which was sent to inform people about changes made and successes achieved, can be considered as one of the top CSFs, although there were sometimes communication barriers, due to the presence of different languages. The final factor mentioned was top management support and involvement, although an interviewee acknowledged that not all managers in the organisation were supportive. The new VP was seen as having an important role to play in changing the views of these managers.

The participants in Organisation E cited strong commitment and support from top management as the most important factor in the success of its LSS pilot project. This support arose from top management's decision to prioritise quality and process improvement (though none of these managers had yet been certified for LSS). The availability of training and education was seen as having contributed to the success of LSS, although the LSS team remained very small, with just six members. Effective communication (via weekly meetings and occasional reports) between the quality department and top management was a CSF; this was further facilitated by the communication loop set up by the project sponsor. The fourth factor was the process owner's willingness to cooperate with the LSS team, while the fifth was the availability of financial resources; other physical resources, though limited, were made available promptly as required. Table 5.6 shows the top five CSFs for LSS in each of the case organisations.

Table 5.6: The top five CSFs in the case organisations

Organisations	Top Five CSFs for Lean/Six Sigma
A	1-Top management support and involvement 2-Training and education 3-The availability of resources 4-Selection of the right value adding projects 5-Being able to finish projects on time
B	1-Strong leadership 2-Training and education 3-Top management support and involvement 4-Selection of the right value adding projects 5-Skilled Lean practitioners
C	1-Top management support and involvement 2-The availability of data 3-Recruitment of more qualified and highly experienced people 4-The ability to change people's mindsets 5-Training and education
D	1-Training and education 2-Willingness and motivation of staff to be involved in training and projects 3-Skilled and experienced leadership 4- Communication 5- Top management support and involvement
E	1-Strong commitment and support from the top management 2-Training and education 3-Communication 4-Cooperation from process owner 5-The availability of resources

Table 5.6 shows that the CSFs varied from one case organisation to another, especially when looking at the top three CSFs. However, some common factors were cited by interviewees across all the case organisations, such as training and education and top management commitment and support.

5.3.5 Challenges for LSS implementation

For Organisation A, interviewees reported several challenges to its LSS implementation (as summarised in Table 5.7):

1- The LSS team's main challenge was managing change; when it initiated a project and introduced changes in a department, these were invariably challenged by most members of the department.

2- Getting everyone involved and interested in LSS projects and training was very challenging, as it required changing employees' perception of how well they were doing and what they were contributing.

3- Data collection for LSS projects is highly effort-intensive. Some departments had no clear roles, responsibilities or metrics to determine the work.
4- The way projects are executed under DMAIC may in practice differ slightly from what has been learned in training.
5- In other companies, an uncooperative team member could easily be replaced, but in Organisation A, it was very hard to find an alternative as everyone was busy in ERP (Enterprise Resource Planning).

Organisation B's representatives also cited a number of challenges that it faced during the Lean implementation process:

1- It was difficult to allocate time for running training and workshops for Lean managers, due to their work commitment. This explained the slow progress of Lean deployment in the organisation and the delay in training delivery.
2- There was a resistance to change and the deployment of CI methods, including Lean, from people who did not realise the importance of CI.
3- Changing the organisational culture across the group as a whole was seen as a major challenge.
4- As with Six Sigma, having trained and formalised a good team of Lean practitioners, the company feared losing them to other organisations.
5- Gathering accurate data to baseline projects was a major challenge; meetings that had been arranged to address the issue were felt to have been largely unproductive.

In Organisation C, it was perceived that its implementation of Six Sigma faced many challenges, including:

1- Creating the infrastructure that allows LSS to be implemented. More academics needed to be trained in Six Sigma, but there was as yet no provision for this.
2- Data collection was generally problematic in Saudi Arabian universities, because data is either not recorded or not entered into databases.
3- Traditional management approaches prevailed, with business functions working in silos. Changing the mindset of staff towards work and change was the biggest challenge.
4- The current unsatisfactory system for selecting projects (by the dean of scientific research) was seen as stalling Six Sigma. Proposals had to be submitted by the BB to the dean for approval and funding, but none of the submitted projects had so far been

selected. The BB argued that this could be because the dean lacked awareness of Six Sigma or saw it as a low priority.

5- Many nationalities were working in the university, making language barriers an additional hurdle. Data collection was even more challenging because the staff in the quality department were non-Arabic speakers, while most of the academic staff were Arabic speakers.

Although Organisation D was a multinational organisation with wide experience in Lean and Six Sigma, there were still a significant number of challenges facing CI in its Saudi branch. The most frequently cited were:

1- A high level of resistance to change among staff, most of whom were older and set in their ways.
2- The nature of the Saudi market and customers' low commitment created problems; for example, contractors might not collect their purchases at the arranged date, or might even leave them uncollected for several months. Not even the organisation's own production system could be used effectively in Saudi Arabia, because of the nature of the country and its customers.
3- Language barriers made communication difficult between employees from different countries (there were more than 50 nationalities represented in the company at the time of the study). These employees may also struggle to adjust to working in a different culture and environment.
4- Aligning Lean and Six Sigma deployment practices in the three Saudi plants with practices in the company's other global plants could be problematic.
5- A lack of understanding of how to select LSS projects. Currently, BBs and GBs suggested projects to address specific problems, but the interviewees felt that project selection should come from top management.

The challenges faced in Organisation E included:

1- Lack of physical resources and qualified employees during project execution; finding local, qualified LSS practitioners was especially difficult.
2- The most common challenge across the service sector is the lack of data and of systems for saving data.

3- The training provided by the organisation had so far extended only to a few employees and managers. The process owner and his team in the medical devices department had not received any training in LSS.
4- Changing the culture is a major barrier, especially in the public sector in developing countries.
5- Resistance was expected from some staff as LSS was rolled out across the organisation. People who believe that they are doing their work properly and producing the right outcomes are likely to refuse to change.

Table 5.7: Top five challenges/ inhibitors encountered in Lean/Six Sigma implementation

Organisations	**Top five challenges/ inhibitors encountered in Lean/Six Sigma**
A	1-Resistance to change 2-Getting everyone involved and interested in LSS projects 3-Unavailability of data 4-Using DMAIC phases is slightly different in practice than in theory 5-Lack of manpower
B	1-Finding time for training 2-Resistance to change 3-Changing the culture 4-Losing Lean team members 5-Unavailability of data
C	1-Creating the infrastructure for LSS 2-Unavailability of data 3-Changing people's mindsets 4-Lack of project selection system 5-Lack of communication due to language barriers
D	1-Resistance to change 2-Lack of customer commitment 3-Lack of communication due to language barriers 4- Aligning Lean and Six Sigma deployment in Saudi plants with those in other global plants 5-Lack of project selection system
E	1-Lack of manpower 2-Unavailability of data 3-Lack of training 4-Changing the culture 5-Resistance to change

Table 5.7 highlights the top five challenges encountered in LSS implementation in the case organisations. These challenges were common across several organisations, such as unavailability of data and resistance to change, whereas there were some other challenges that emerged, especially in organisations A and D.

5.3.6 Impact of organisational culture and leadership on LSS

In Organisation A, the interviewees reported a very positive organisational culture that supported LSS, while LSS had, in turn, completely changed the culture. As the mass training of BBs progressed, the initial fear of change and the unknown (85% of employees questioned why the company needed Six Sigma at all) had given way to supportiveness, and staff who had been working in the organisation since before its introduction had noted a positive cultural change. For example, employees were more aware of the importance of data gathering and analysis and the need for statistical analysis. As Six Sigma became embedded in the culture, employees were increasingly able to respond swiftly to problems and to adopt a project-based approach. As a multicultural organisation, A was well placed to bring together new and different ways of thinking. Moreover, the staff gained the confidence to experiment without fear of failure or blame. This extended to the creation of a dashboard for employees at all levels to share their ideas about how their job might be improved. The mechanism existed to capture these ideas, go through them and translate them into projects.

The main reason why the culture had changed was believed to be the leadership's commitment to training and continuous learning and development, but it had also been driven by the owners, who were open to new ideas and new ways of doing things. In other words, Six Sigma had the maximum support from everyone at the top. Initial fears that Six Sigma would not be suited to Saudi Arabian culture proved groundless – here too, people are trying to do things better. In truth, Organisation A's experience highlights that organisations pursuing CI face the same challenges, wherever they are.

Organisation B found it a challenge to create a supportive organisational culture for Lean and Six Sigma. Despite the Lean team's belief that the culture could be changed, it struggled to overcome the resistance of employees, many of whom had been working in the same position for many years. It also had to compete against numerous other initiatives and contend with recent upheavals in the organisational structure.

One of the interviewees highlighted the fact that the organisational culture was 'strongly negative'. He argued that in Saudi Arabia employees do not have the same competitive pressures that people have in Western Europe or the USA. One reason for this is that the high level of job security and service-based (rather than performance-based) reward systems offer little incentive for self-development. In some departments, the essential features of a job may remain unchanged for decades, so the employee will not necessarily be penalised for not developing their skills. In the absence of competitive pressure, there is nothing to motivate them to change. Only senior staff are likely to feel such competitive pressure and therefore the need to develop their skills. However, he believed that the culture in Organisation B was slowly changing, and the VP was optimistic that they would be able to deliver improvements in due time. Lean and Six Sigma constituted, in his view, a major developmental step, both professionally and personally. Their success would depend heavily on the leadership, which is where the culture change also has to start. Accordingly, a key focus for the organisation was to train senior leaders and get them out of their offices into the plant, so as to improve their understanding of processes and problems.

In Organisation C, interviewees judged the culture to be unsupportive of LSS, because the basic platform and LSS infrastructure were missing. Their view was that the culture needed to be improved before any CI initiatives could be attempted. In contrast, the quality assurance manager asserted that the university could not have achieved the level of quality it needed to secure accreditation without a positive culture and top management support. There was believed to be a general receptiveness to change in the culture (for example in terms of course content and assessment methods), but this needed to be supported by leaders at all levels. However, while those in senior positions were seen as democratic and open to change, it was perceived that middle managers and lecturers tended to be more bureaucratic.

Globally, the culture in Organisation D was seen as strongly supportive not only of Lean and Six Sigma but also of other CI initiatives and the organisation's own production system; there was a Six Sigma community inside this multinational that continuously encouraged BBs and GBs to conduct projects and had created a culture supportive of innovation and creativity. Within the Saudi organisation, however, it appeared opinion was divided between those who were supportive of CI and keen to implement LSS, and those who feared these innovations might expose their weaknesses or threaten their position. The multinational nature of the workforce also complicated the culture of Organisation D: while undeniably expanding the pool of potential ideas and input into LSS, language barriers and competition between foreign and Saudi employees was seen to have a negative impact. Nevertheless, it appeared that there had been a noticeable improvement in the culture of Organisation D, and many challenges had been tackled since the arrival of the new VP. As part of his efforts to make the leadership more supportive of CI, he established a programme to improve leadership skills in the company, created a cross-functional team and introduced an open door policy.

It was suggested by participants that although the organisational culture in Organisation E *seemed* supportive of LSS – the LSS team was fully backed by the executive manager, who authorised it to do whatever was necessary to make LSS a success –in reality, there was significant resistance to change at all levels. Most of the employees were reluctant to change how they had worked for many years, and the managers in this public sector organisation did not have the authority to force them. The LSS team faced no resistance during the pilot project in the medical devices department, but attempts to execute a further five projects in the same department were blocked by the finance and HR departments. The reason given was that top management was looking for LSS projects at the organisational rather than the departmental level. The quality team sought to avoid a blame culture, preferring to see mistakes as learning opportunities. Since there had not, at the time of the interviews, been any major changes in the organisation, it was not yet clear what role, if any, the leadership was playing in changing the culture. Table 5.8 presents the impact of organisational culture and the role of leadership in LSS deployment in the case organisations.

Table 5.8: The impact of organisational culture and the role of leadership on LSS

Organisations	Impact of the culture on Lean/Six Sigma deployment	Leadership role in regard to LSS
A	Strongly positive (5)	Leaders were visionary and very supportive of LSS
B	Somewhat negative (2)	Lean leaders were in training programmes to improve their leadership skills
C	Somewhat positive (4)	The role of leadership was not observable yet
D	Somewhat positive (4)	New programmes introduced to improve leadership skills that support LSS
E	Somewhat positive (4)	The role of leadership was not observable yet

Note: The impact of organisational culture was measured by a 1-5 Likert scale, where 5= organisational culture has a strong positive impact on LSS and 1= organisational culture has a strong negative impact on LSS.

The main observation from Table 5.8 is that there is seen to be a clear impact of leadership role on organisational culture and the deployment of LSS. Visionary and supportive leadership can create a positive organisational culture for LSS and vice versa.

5.3.7 Successful and failed LSS projects and project selection

Organisation A had implemented around 150 Six Sigma projects and 30 LSS projects successfully, in most of the departments across the organisation. Although there was no recorded data about the number of failed projects, several reasons were given to account for why projects failed:

1- When the first group of BBs returned from their training in USA, the organisation had unreasonably high expectations, even though the right support structure was not yet in place.
2- Initially, BBs attempted to do too much in projects, with the result that these projects took too long and consumed more resources than was necessary or planned for. Too many projects took a long time but yielded no tangible results.
3- Top management initially gave little support because it did not fully understand what BBs were trying to do.

The LSS team learned valuable lessons from these early failures, in particular, that projects have to be clearly targeted. To say, truthfully, ‘I don’t know’ and ‘I cannot do this’ had become acceptable to the management, and staff were encouraged to share their knowledge, successes and failures. One MBB asserted that no project is really a failure because everything adds value to the company; even if it does not generate savings, it will still add to the BB’s understanding of the process. Six Sigma and LSS projects took around six months to one year to be completed, depending on the project’s scope.

In project selection, the priority was given to projects that enhance process efficiency. Some projects were selected by its partner Caterpillar, with the aim of helping Organisation A to become more closely aligned with its partner organisation.

In Organisation B, around 50 Lean projects had been implemented across the organisation, including ongoing projects. The organisation planned to carry out a ‘health check’ on ongoing projects to determine whether they were successful, but there was no specific measurement for success. At the beginning of its Lean journey, the organisation experienced two failed projects in the maintenance and engineering department. These projects failed because, due to lack of experience at the beginning of Lean journey, the Lean team copied its joint venture partner and chose tools that were inappropriate to the project scope. However, it learned from its mistake, that is: never directly copy from other organisations, even if they are in the same business.

The first set of projects selected by the Lean team included 16 projects designed to improve process efficiency in the maintenance and engineering department. For the second set of projects, each department was asked to nominate one Lean focal point. This technique allows departments to choose improvements that will be beneficial to them. The responsibility for selecting the project is given to the individual who will then go on to carry it out. This individual is expected to work with others in that area to produce a proposal. Project proposals are thus bottom-up, although the selection of individuals is top-down. This approach ensures that Lean projects are aligned with the organisation's business goals. The typical cycle time of Lean projects in the company was six weeks, maximum. These projects were using basic and fundamental tools of Lean rather than the more advanced tools.

Organisation C reported that they had experienced no failed projects. There were two reasons given for this: firstly, only four BB projects had been conducted to date (in the teaching hospital), and these related to risk management, risk assessment for health and safety, and safety improvement, and secondly, the Six Sigma team had extensive experience, especially in terms of data analysis and using statistical tools.
Project selection was based on the need to address chronic problems, which were judged using historical data. Selecting projects was the responsibility of the Six Sigma team within the quality assurance department. Each project lasted around a year.

Organisation D had a database to record implemented projects, which showed that around 30 Lean and Six Sigma projects across the organisation's departments had been conducted up to the date of the study. No data was available on the number of failed projects, although one of the interviewees said he had been involved in one Lean project that had failed due to lack of top management commitment and involvement. In fact, little data was available in Organisation D, and what there was closely guarded. Six Sigma projects usually took between seven months and a year, while Lean projects took around two months.
The most important consideration when selecting projects was customer feedback. The second was to select projects that would address identified problems, especially on the shop floor, where the need was perceived to be greatest.

Organisation E had only implemented one BB pilot project, in the medical devices department, in 2013, which was completed successfully. This project was selected because the department was facing more problems than any other and was significantly underperforming. The main problem was with issuing a certificate for medical devices, which took 35 days. The project sought to map the process to understand where things were going wrong and to raise output without increasing manpower. The project was completed in four months and the results were very satisfactory i.e. the process was improved and the time taken to issue a certificate was reduced from 35 days to 12 days.

Table 5.9 summarises the key findings discussed above regarding project implementation in the case organisations.

Table 5.9: Successful and failed LSS projects and project selection in the case organisations

Projects details	A	B	C	D	E
Number of successful Lean/Six Sigma projects to date	150 Six Sigma projects and 30 LSS projects	50 Lean projects (total projects including ongoing projects)	4 Six Sigma BB projects	30 Lean and Six Sigma projects	1 LSS BB project
Duration of projects	6 months to one year	6 weeks for Lean project	Up to 1 year for Six Sigma project	7 months to 1 year for Six Sigma project and 2 months for Lean project	4 months for LSS pilot project
Project selection	Top priority was enhancing process efficiency	1-Project must be able to improve process efficiency 2-Each department had to nominate one Lean focal point and to prioritise its own projects	Projects chosen to address chronic problems	1-Customer feedback 2-Projects that help to solve a problem, especially on the shop floor	Chosen department was seen as the one in most urgent need
Number of failed Lean/Six Sigma projects	No data recorded	2 Lean projects	No failed projects	1 Lean project	No failed projects
Reasons for failure	1-High expectations from BBs 2-Wide project scope 3-Lack of top management support (in the past)	Copying other organisation’s experiences	Not available	Lack of top management commitment and involvement (in the past)	Not available

Table 5.9 clearly shows the weaknesses in deploying projects in the case organisations. There is a lack of consistency in the results and each organisation had a different duration for Lean and/Six Sigma projects. It was observed that there was a lack of data regarding the number of

the failed projects, reasons for project failure and the growth in the number of projects since the launch of LSS.

5.3.8 Role of HR and IT in LSS

The participants from Organisation A stated that the HR department played a major role in developing and maintaining its policy in relation to rewards for LSS. It had also helped to build LSS infrastructure by developing a policy for employee training. Finally, the department was responsible for recruiting Six Sigma staff. Like any other division, HR itself was also a user of Six Sigma; if it wanted to execute a LSS project, it could contact the Six Sigma team and ask for help. For instance, a LSS project was conducted in the HR department in the recruitment process to find out about the successful candidates for jobs who had then rejected the job offers from the organisation. The HR VP was the BB for this project and he found that the main reason for this phenomenon was the long waiting time for the job offer to be issued, which was six months.

The IT department was reported to play a much more limited role, getting involved only when a project required digital support.

Organisation B had no in-house HR or IT departments as these were based at the group headquarters.

In Organisation C, the quality assurance department had not yet requested any support from HR at the time of the interviews, but it was explained that it expected to collaborate with both HR and IT departments in the near future as it implemented Six Sigma projects.

In Organisation D, the HR department played a major role in supporting Lean and Six Sigma, by helping the CI team to raise awareness and understanding of LSS. HR planned the CI training, with leadership training being its current focus. This training targeted team leaders (including those in HR), to make sure that they understood LSS and Lean manufacturing. HR also provided help with hiring, redundancy and other issues related to people management, and with rewards for the Lean/Six Sigma team. In contrast, a lack of communication between the quality department and IT meant the former was receiving no support from the latter.

The LSS project implemented recently in Organisation E received no support from the HR or IT departments, but it was intended that future projects would involve collaboration between these and the quality department.

Table 5.10 summarises how the case organisations performed in terms of the role of IT and HR departments in LSS.

Table 5.10: Role of IT and HR departments in LSS implementation in the case organisations

IT and HR	A	B	C	D	E
IT's role in LSS	Minor role	No role	No role	No role	No role
Rewards for LSS team	Applicable	Not applicable	Not applicable	Applicable	Not applicable
HR's role in LSS	Major role	Minor role	No role	Major role	No role

From the table above, it can be seen that there is a clear deficiency in the role of IT across the case organisations, while HR has a major role in only two organisations out of five. Financial reward was also ignored in three of the organisations, which can seriously affect the sustainability of any CI initiative.

5.4 Motivational factors for LSS deployment (RQ2)

The theme of motivation was investigated from two angles: those factors that have motivated the case organisations to implement Lean and/or Six Sigma (see Table 5.11) and those that motivate individuals to join LSS teams.

Organisation A's motivation to embrace Lean and Six Sigma came from Caterpillar, its supplier, who provided a LSS implementation roadmap for the training of its executives and employees. Once it had realised the benefits of LSS, Organisation A's owners and top management were keen to train more people and roll out more projects, and it is now one of the biggest LSS trainers in the Middle East. One of its main motivations was its desire to become more process-driven, but it also wanted to strategically align itself with its suppliers, all of whom run CI programmes. According to the interviewees it now shared some of the same targets as Caterpillar, as evidenced by its LSS project aimed at increasing market share. Other motivators for LSS were the desire to reduce waste and improve process efficiency, to change employees' mindsets, increase customer satisfaction and make cost savings.

Employees were largely self-motivated to become involved in the LSS team and carry out projects. Employees were motivated by the opportunity to learn and be creative, and to work in a job that is challenging and not routine. They also received financial reward for joining the team, depending on the savings from the project. The organisation used a 5-level reward system, e.g. a Level 1 reward was for projects that saved a minimum of $66,500 and there was a formula for calculating the amount of the reward for each team member. Extrinsic motivation came from the prospect of promotion to MBB or champion, and the chance to build a good relationship with the sponsors.

Organisation B adopted the Six Sigma then Lean approaches, following the example of its US-based joint venture partner. It was motivated in this by a desire to reduce waste and improve process efficiency and output quality, to foster relationships between management and employees and to restructure its processes to ensure sustainability.
Employees in Organisation B were self-motivated to become involved in the Lean and Six Sigma programmes. Some interviewees were interested in Lean and Six Sigma because they loved the experience of making improvements and seeing projects come to life, while others were interested to learn a new systematic approach and a much better way of ensuring sustained quality and efficiency. However, there was also the recognition that becoming a Lean practitioner or Six Sigma champion could lead to promotion and higher pay, a key consideration in Saudi Arabia, where status is regarded as important. None of the employees was motivated by the prospect of short-term financial rewards, since teams were not rewarded for successful projects.

Organisation C's teaching hospital was motivated to introduce Six Sigma because it wanted to build a culture of quality, reduce waste, improve performance and customer satisfaction and move up local and international university rankings.
Those in the Six Sigma team wanted to improve the curriculum and increase student and patient satisfaction. No financial reward was available, but the interviewees had strong intrinsic motivation; they spoke of the personal satisfaction they obtained from seeing change happen and building a culture that supports quality and CI. Some saw it as their responsibility, as a feature of Saudi culture, to disseminate their knowledge to help other staff members.

In Organisation D, Lean was introduced by its French parent organisation to cut costs by reducing production lead-time from 150 hours to 60 hours and wastage by at least 30%.

Other motivating factors were to improve product quality, tighten control over the process, improve process efficiency and increase customer satisfaction.

Individual employees were motivated to learn about Lean, Six Sigma and the organisation's own production system because they saw these as providing useful tools to reduce waste and minimise delays, enabling them to meet their job targets. Beyond this, however, they were keen to understand LSS, because they saw that it is being increasingly widely employed across all sectors. There was also financial reward for LSS team members, which was a fixed amount in any project, regardless of the amount of saving from the project.

In Organisation E, LSS was introduced by a group of employees who had trained abroad. The organisation's motivation to introduce LSS was the desire to improve process and employee efficiency, reduce waiting time (e.g. for issuing certificates) and eliminate NVA activities.

At a personal level, LSS team members were motivated by the chance to be at the centre of things in a position of influence, and to enrich their CV. They saw it as an opportunity to develop their team working skills and to help build something from scratch.

Table 5.11: Top five motivational factors for introducing LSS in the case organisations

Case organisations	Top five motivational factors for implementing Lean/Six Sigma
A	1- To become more closely aligned with suppliers 2- To remove waste in the process 3- To make financial savings to the bottom-line 4- To become a process-oriented organisation 5- To increase customer satisfaction
B	1- To reduce the 7 types of waste in the process 2- To improve process efficiency and effectiveness 3- To improve output quality 4- To create engagement between management and employees 5- To restructure the process to ensure Lean sustainability
C	1- To build a culture of quality 2- To improve performance 3- To raise the university's international and local rankings 4- To reduce waste in the process 5- To increase customer satisfaction
D	1- To increase financial benefits by reducing production time and waste 2- To improve product quality 3- To control the process 4- To improve process efficiency and effectiveness 5- To increase customer satisfaction
E	1- To improve process efficiency 2- To reduce the time taken to provide services 3- To eliminate NVA activities and waste 4- To increase employee efficiency

Although organisations A and D were keen to demonstrate financial savings, the majority of the projects were not achieving what would expected to be achieved at the end of the project. The remainder of the case organisations were not interested in saving money or saving money was not the highest priority for them.

5.5 Organisational learning and its link to LSS (RQ4)

Since one of the objectives of this research is to assess the extent to which the case organisations can be described as learning organisations, it was essential to investigate their organisational learning practices and the influence of OL on LSS implementation. Table 5.12 summarises the top five organisational learning practices in each organisation.

Organisation A supported organisational learning and knowledge sharing from the beginning by using newsletters to communicate the success of projects throughout the organisation. Later, a database was set up so that anyone could find out about past and ongoing LSS projects. This system helped the organisation to push ideas, share success stories and publicise the benefits of each project. Caterpillar also has a comprehensive and highly regarded database called 'The Knowledge Network', which it shares with its dealerships around the world. In addition, it sponsors a 'Deployment Champion Excellence Award'; besides spurring competition between dealers, which gives them the chance to learn from other dealers in neighbouring countries.

Believing that success does not come without failure, Organisation A regarded failed LSS projects as a valuable learning resource. Knowing that failure would not lead to blame, employees were encouraged to learn from mistakes as much as from best practice. They were also encouraged to share information, knowledge and stories. The employees shared an open-plan work area, facilitating the free exchange of ideas between different nationalities and cultures. One positive learning practice was the weekly meeting with top management to share objectives and information and analyse obstacles and complaints.

In Organisation B, the Lean deployment leader had a major role in raising awareness and learning throughout the organisation, though progress was proving slow. The organisation had three main mechanisms for learning. The first involved learning lessons about safety from previous incidents (whether these occurred internally or in other organisations in the sector). The organisation's LFI (Learning from Incident) committee was responsible for employee safety. The second mechanism involved the sharing of information and knowledge with sister organisations within the group. Thirdly, the organisation's joint venture partners supported learning by providing a quarterly forum for Lean leaders to share practical experience.

According to the interviewees, a major drawback in Organisation B was that the prevailing attitude towards failure was to take it personally, with the result that individuals were less inclined to discuss their failures. In that respect, therefore, the organisational culture did not support the sharing of information.

In Organisation C as a whole, it was not acceptable to criticise others (particularly managers) or to point out their weaknesses. The participants reported that there was, as yet, no general culture of sharing mistakes and limitations, although a few academics were trying to encourage this as a first step to bringing about improvement. The university did not benchmark against other universities in terms of CI practice, although it did benchmark against similar universities in Saudi in terms of vision and mission. The interviewees reported that it learned from similar universities in the UK and USA through their journal publications. The teaching hospital had its own organisational learning practices: specifically, a risk management system and a model that helped staff to learn from mistakes. The implementation of ISO had supported learning by standardising tasks and procedures, making it easier to identify deviations and to replicate good practice.

In Organisation D, organisational learning was guided by the parent organisation, which had a policy of sharing best practice to encourage competition between plants. CI-related knowledge and experience were also shared via the organisation's intranet. At plant level, meetings offered a forum for reviewing changes, while communication boards and daily e-mail bulletins were used to share changes and success. The organisation had adopted the 'learning by doing' technique to spread the Lean and Six Sigma approaches to all departments. This project-based approach was effective because it allowed employees to learn together and exchange knowledge. The first project was always the worst, due to lack of experience, but the employees were encouraged to learn from their failures.

The organisation's own production system allowed greater exchange of knowledge between Organisation D and its sister organisations around the globe. It promoted the sharing of information right across the plant by means of meetings between staff at all levels, from operators to top management. This information was then made available to everyone on the intranet.

According to the respondents, because of its confidence that it was producing great products and that its customers were satisfied, Organisation D had never seen the need to find out more about its competitors. It did not benchmark against other organisations because, as a highly successful global energy management specialist, it considered itself a benchmark organisation.

Organisation E was in the process of building an organisational learning culture. At the time of the interviews, organisational learning activity was limited to the discussion of problems at departmental level; information was not shared with other departments. Having said this, the participants pointed out that the LSS team was asked to produce a presentation and report after the completion of the LSS pilot project to show what had been achieved. There was also a willingness to learn from mistakes, which the LSS team considered normal and inevitable. Managers encouraged their employees to share their mistakes, and were urged by top management not to allow a blame culture. There was also an open door policy, extending even to top managers, that encouraged employees to ask whatever they wanted or report any concerns. Overall, organisational learning in the company was still in the early stages, and would need more support from top management if it was to become part of the culture.

Table 5.12: The top five organisational learning practices in the case organisations

Case organisations	Top five organisational learning practices
A	1-Internal database recording LSS projects (previously newsletter) and sharing knowledge 2-Learning from failed projects and mistakes 3-Learning from success and best practices 4-Sharing knowledge and information externally through the knowledge network
B	1-Learning from past incidents (internal and external) 2-Sharing problems and stories from one organisation with the rest of the group 3-Learning from the joint venture partners through quarterly or half-yearly engagement
C	Organisational learning practices not yet established in the university outside the teaching hospital, which recorded mistakes systematically
D	1-Policy of sharing best practice and knowledge via the intranet, regular meetings, communication board and daily e-mails 2-Learning by doing 3-Learning from new projects, mistakes and failures 4-Learning from sister organisations around the globe 5-Using the organisation's own production system supports learning
E	1-Discussing problems openly at departmental level 2-Sharing information and knowledge about LSS project through a presentation and report

Table 5.12 cites many organisational learning practices supporting the deployment of LSS; yet, these practices were not being employed in a regular and systematic manner and they were simple and basic, such as sharing knowledge and experience of LSS deployment and learning from failure and mistakes.

5.6 Chapter summary

This descriptive study has provided a detail picture of the current status of LSS implementation in Saudi Arabian organisations, through an online survey and multiple-case studies in 5 large organisations. This chapter has presented a within-case analysis, based on the themes that were formalised at the beginning of this chapter, as shown in Figure 5.1

The key observations in this chapter are: there was no consistency in training duration and certification requirements, such as specifying the number of projects and amount of savings across the organisation. There was also an obvious weakness in LSS infrastructure in most of the cases. DMAIC was the most common methodology for LSS projects and DFSS methods were used in manufacturing organisations, while tools and techniques were very basic and simple. Organisations were avoiding the use of more advanced statistical tools and techniques, due to lack of experience and believing that these techniques are more applicable to manufacturing and production lines than in the service sector.

Although LSS had yielded benefits, these were mostly soft, with hard benefits rarely being generated. This part of the study highlights the two most common critical factors in order to achieve successful LSS implementation: training and education and top management commitment and support. However, it was found that CSFs varied from one case organisation to another, especially when looking at the top three CSFs. CI initiatives sometimes failed because of management change, but an unwelcoming organisational culture and resistance to change from senior employees appear to have been even bigger barriers in some organisations in this study. In addition, a negative organisational culture and lack of leadership were slowing the deployment of LSS, although respondents in some organisations believed that the culture was improving over time.

In terms of project implementation, there was a lack of consistency in the duration allowed for Lean and/Six Sigma projects to be completed. It was also observed that there was a lack of data regarding the number of failed projects and reasons for project failure and also a lack of specific figures about the growth of projects since the launch of LSS. Furthermore, there was a clear deficiency in the role of IT across the case organisations, while HR played a major role only in two organisations out of five. Financial reward was also ignored in three organisations, which can seriously affect the sustainability of any CI initiative.

Although a few organisations were motivated to deploy LSS to demonstrate financial savings, the majority of the projects were not achieving what they were expected to achieve at the end of the project. The remainder of the case organisations were not interested in saving money or saving money was a lower priority compared to other motivation factors such as improving quality and process efficiency.

Finally, organisational learning practices supporting the deployment of LSS were not employed in a consistent manner. These practices were simple and basic, such as sharing knowledge and experience of LSS deployment and learning from failure and mistakes.

Further analysis is necessary to explore in more detail the similarities and differences across cases and sectors: for example, between public and private, and local and multinational organisations. This is the aim of the next chapter, which draws on the themes explored in this chapter to conduct a cross-case analysis of the participating organisations.

CHAPTER SIX
Cross-Case Analysis and Findings

6.1 Introduction

The first part of the case study analysis (within-case) having been presented in Chapter 5, this chapter presents the cross-case analysis. This was chosen as the most appropriate technique for analysing multiple case studies. The analysis, which aims to answer research questions 1, 2 and 4, is both case-oriented and variable-oriented (Miles and Huberman, 1994).

6.2 History of quality practices across the case organisations

The case organisations were all well-established: Organisation A was the oldest, at 60 years old, while Organisation E, the newest, had been operating for only thirteen years. B was the smallest, with 900 employees, while C was the largest, with 4500.

All the organisations had a history of implementing at least two quality initiatives, including ISO, TQM, Lean, Six Sigma and LSS. The private sector organisations A, B and D had been certified for different versions of ISO (e.g. ISO 9001, ISO 14001) since the 1990s, in A and B, and early 2005, in D. These organisations' higher awareness of quality standards and CI methods may be attributed to the fact that they were in joint ventures with multinationals (A and B) or had a parent organisation in Europe (D). In contrast, the public sector organisations, C and E, were in the early stages of implementing ISO: at the time of this study, only the teaching hospital in Organisation C and the medical devices department in Organisation E were ISO certified. In all the case organisations, ISO was used as a foundation for other quality practices such as Lean and Six Sigma.

Organisations A, B, C and D had introduced TQM in the 1990s (it had never been adopted by E), although it was subsequently replaced by Six Sigma in Organisations A (in 2003), B and D (both in 2005). Organisation D had already embraced Lean in 2004 (as part of its organisation's own production system), but Organisation A did not adopt it until 2010, while Organisation B introduced Lean in 2012. Organisation E adopted LSS for its pilot project in 2013, while C had not executed any Lean project but Lean tools were used in some Six Sigma projects.

The findings show that Six Sigma was the most widely used approach, having been implemented in all the case organisations at some point during the past 12 years. Organisation A had used Six Sigma the longest (since 2003), although it had been supported by Lean since 2010. Organisations B and D had each used Six Sigma for three years but were forced to halt the initiative because of leadership changes. However, both organisations had recently restarted the deployment of Six Sigma to support Lean. Organisation C had been deploying Six Sigma for two years, but was finding progress very slow.

Ranking the case organisations in terms of their CI history, Organisation A had the longest sustainability of CI methodologies compared to the others. It had achieved a range of ISO certifications and had implemented several CI methodologies, which it had maintained over a long period, as well as having a plan for sustainability and further improvement. In contrast, Organisations B and D had deployed a range of CI methodologies but had failed to sustain them, wasting significant resources in the process. The public sector organisations, C and E, rank lowest, because of their limited experience with quality and CI initiatives. Both organisations were in the early stages of the journey, but both were obviously interested in improving their level of LSS deployment.

6.3 Current status of LSS (RQ1)

This section aims to compare the current status of LSS across the case organisations, comparing the findings with the literature. It is organised according to the themes identified in Chapter 5 (which were originally developed from the literature review presented in Chapter 2).

6.3.1 Awareness, infrastructure and training for LSS

6.3.1.1 Level of LSS awareness

When the interviewees were asked how aware their organisation and its employees were of Lean and Six Sigma, their answers revealed major differences between the case organisations, particularly in terms of employee awareness. Organisation A had the highest level of awareness; everyone trained as a YB, and top managers and owners were fully aware of LSS and its potential benefits. Employees' awareness was lower among the other organisations and depended on the availability of training; Organisation B, which had delivered Lean awareness sessions to all its employees, was confident that everyone in the organisation, including the CEO and top management, was familiar with Lean, but the interviewees admitted that Six Sigma awareness was still low. Similarly, in Organisation D, employees were more aware of Lean than of Six Sigma because Lean was a large part of the organisation's own production system (although the participants claimed that Six Sigma awareness was increasing as training progressed).

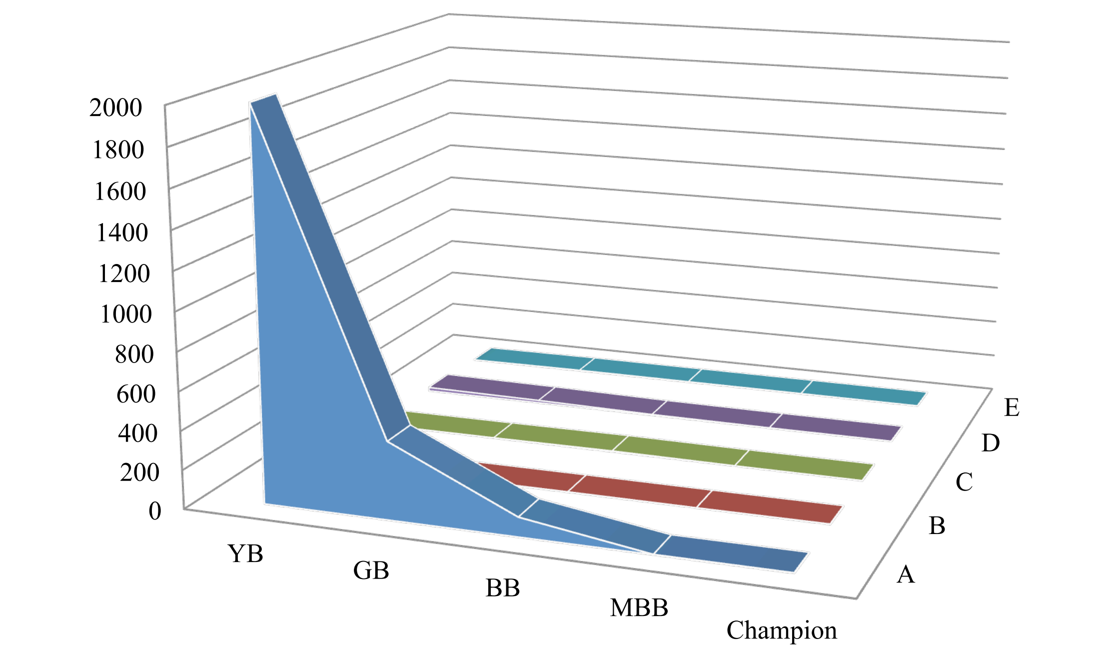
Organisations C and E (public sector) not only had the lowest level of employee awareness, but institutional awareness was also very low compared to the other organisations in the study. In the case of Organisation C, the preoccupation with academic accreditation meant that only the quality department and the teaching hospital had paid much attention to LSS. It was apparent that in both public sector organisations, only the LSS team had a high level of awareness and experience of CI, while other departments knew nothing about the issue. The author argues that LSS is not meant for the LSS team alone, and that CI is everyone's responsibility and not exclusively an issue for the CI team. If responsibility for LSS or CI is reserved to limited groups of people, organisational culture will not be changed and, moreover LSS cannot be sustained over time (Antony, 2013; Liker, 1997). It would therefore be desirable for these organisations to give all staff awareness sessions or even YB training as a first step to changing the organisational culture (Gupta, 2005). Since Organisation C already had four BBs and E had two BBs and a MBB, there is no reason why this training could not be run internally. However, in the case of Organisation C, the researcher observed a lack of communication between the university's quality department and other departments and faculties; indeed, some of the faculty interviewees were surprised to hear that there was a LSS team in their university. The finding highlights that not just training but also better top down communication would be needed to raise employees' awareness of active CI initiatives in their organisations. Communication plays an important role in successful LSS companies and it was cited as one of the top CSFs for successful organisations (Barney, 2002; Henderson and Evans, 2000).

From the above, it can be inferred that the lack of LSS awareness at the institution level was due to the organisational culture, leadership and communication from senior managers to other employees.

6.3.1.2 LSS infrastructure

At the time of the study only Organisation A had achieved the infrastructure recommended by LSS scholars (Breyfogle, 2003; George, 2003; Harry, 1998; Laureani and Antony, 2012; Snee, 2004; Voehl et al., 2013), that is, one BB for every 100 employees and one MBB for every 15 to 20 BBs. Organisation A was also the best in terms of YB and GB coverage, with all employees being trained as YBs (by the MBB) and 20% being trained as GBs. The rest of the organisations had very poor infrastructure in comparison (see Figure 6.1). Worst of all were Organisations C and E, which had no CI deployment champions and only one MBB (E) or none at all (C). The participants from these organisations explained that building the platform and infrastructure for LSS was the responsibility of the quality department, and that LSS implementation would not move forward until these were in place.

Encouragingly, interviewees from all the case organisations agreed that they needed to improve their infrastructure if Lean/Six Sigma are to be sustained in the long-term.



	YB	GB	BB	MBB	Champion
A	2000	400	100	1	1
B	1	0	1	0	1
C	0	1	4	0	0
D	20	14	4	1	1
E	0	3	2	1	0

Figure 6.1: Lean Six Sigma infrastructure across the case organisations

6.3.1.3 LSS training

Lean and Six Sigma training in the case organisations (as presented in Table 5.3) were found to differ depending on the training provider. Organisations A, B and D provided both internal and external training for their employees, using a combination of international training agencies and online training. In Organisation A's case, the training (curriculum, exams, projects) was provided by its main supplier. Organisations C and E did not yet have their own training systems, their LSS teams having been trained abroad.

YB training was carried out in Organisations A, B and D, lasting between one and three days, while GB training of two days was available in Organisation A and 29 hours in Organisation

D. BB training was also available in Organisations A, B and D, with each organisation taking a different approach (as shown in Table 5.3). Organisation B was the only one to require a specified level of saving for BB certification, although after certification some organisations required BBs and GBs to execute a set number of projects per year. For instance, certified GBs in Organisation D were expected to complete three Six Sigma projects per year (as part-time tasks) which increased productivity. MBB training was only available in Organisation A, while Organisation D promoted its MBBs from among its BBs, based on experience and performance record. In all the organisations with a deployment champion (A, B and D), this appointment was based on experience and advanced project management skills.

Although the case organisations had different training procedures and certification requirements, and expected different things from individuals after certification, none of them were employing Saudi or even Middle Eastern-owned training agencies. Organisation A used its joint venture partner's training programme, B trained its employees for Lean in Europe while Six Sigma training was delivered by a European training institute located in Saudi. Organisations C and E sent their employees overseas, and D used online training. These findings suggest that more research is required to investigate the level of training provided by Saudi-owned training agencies and how this compares to the recommendations in the literature. It is also important to investigate the reason why Saudi Arabian companies do not use local training providers and if this due to a serious limitation, or is it because these trainers do not have the required skills.

Moreover, it was observed that there are no standards governing Lean, Six Sigma and LSS training, even in Western countries. As a result, the training materials, exams, projects and required savings differ from one training institution to another, even in the same country. This was apparent in Organisation E, whose BBs trained in two different institutions in the UK. Although of similar duration, the courses differed in terms of the exams and number of projects required for certification.

6.3.2 Methodology, tools and techniques across the case organisations

DMAIC methodology was the dominant LSS methodology in Organisations A, C, D and E, while Organisation B employed the Lean five-stage methodology for Lean projects and PDCA as a cycle for continuous improvement of Lean projects they had executed. Organisations A and D also employed their own methodologies, and occasionally DFSS methodologies such as DMEDI and DMADOV, to design new products. It should be noted at this point that, although the survey results indicated that Organisation A was using PDCA, this was contradicted in the interviews. The anomaly highlights the importance of methodological triangulation in ensuring reliability and generating a deeper understanding of the phenomenon of interest.

All the case organisations had stuck to simple tools and techniques (as shown in Table 6.1), eschewing more advanced tools, primarily because of the unavailability of data. The interviewees described the challenges of gathering the right data and ensuring it is sufficiently comprehensive, but this may be partly attributable to employees' lack of experience in using more advanced techniques.

Table 6.1: Most and less commonly used methods, tools and techniques

	Methods/tools/ techniques	A	B	C	D	E	Frequency
Methodology	DMAIC	✔✔	✖	✔✔	✔✔	✔✔	4
	DFSS	✔	✖	✖	✔	✖	2
Simple tools/ techniques	SIPOC	✔✔	✔✔	✔✔	✔✔	✔✔	5
	Brainstorming	✔	✖	✔	✔✔	✔✔	4
	5S	✔✔	✖	✔	✔✔	✖	3
	Project charter	✔✔	✖	✖	✔✔	✔✔	3
	Process mapping	✔✔	✖	✖	✔✔	✖	2
	VSM	✔✔	✔✔	✔	✔✔	✔✔	5
	Pareto analysis	✔	✔	✖	✔✔	✔✔	4
	Root-cause analysis/5 Whys	✔✔	✔✔	✔✔	✔✔	✔✔	5
	Cause and effect analysis	✔✔	✔✔	✖	✔✔	✔✔	4
	A3	✔	✔✔	✖	✖	✖	2
	Control chart	✔	✖	✔	✖	✔✔	3
	Poke-yoke	✔	✖	✔	✔✔	✖	3
	Affinity diagram	✖	✖	✖	✖	✔✔	1
	Histogram	✖	✔✔	✖	✖	✔✔	2
Advanced tools/ techniques	ANOVA	✔	✖	✔	✖	✔✔	3
	MANOVA	✖	✖	✔	✖	✖	1
	DOE	✖	✖	✖	✖	✖	0
	SPC	✖	✖	✔	✖	✖	1
	Taguchi method	✖	✖	✖	✖	✖	0
	Regression analysis	✔	✖	✔	✔✔	✖	3
	FMEA	✔	✔✔	✖	✔✔	✖	3
	QFD	✖	✖	✖	✖	✖	0
	Kano model	✖	✖	✖	✖	✖	0

✖ Never used ✔✔Most commonly used ✔ Less commonly used

The interview findings summarised in Table 6.1 support the results of the survey in the second phase of the research, confirming that SIPOC, VSM and root-cause analysis/5 Whys are the most commonly used tools across the five case organisations. They also echo the findings from the literature review, which show that these non-statistical tools and techniques are the most widespread. In contrast, more advanced tools such MANOVA and SPC were rarely used, while the Taguchi method, DOE, QFD and Kano model had never been used by the participating organisations for solving quality-related problems. Most of the interviewed BBs explained that this was because these techniques are more applicable to manufacturing and production lines than to the service sector, and that simple tools are generally better suited to transactional environments. In any case, they argued, their projects were straightforward and did not require statistical techniques. The author argues that organisations are not willing to use advanced tools because they are satisfied with using tools that are easy to apply. This could be due to lack of experience in using different tools or lack of understanding of the benefits of using advanced tools.

6.3.3 Benefits from LSS and its impact on business functions

Waste reduction was the top benefit derived from LSS (cited by interviewees in Organisations A, B, C and D), followed by increased customer satisfaction (Organisations A, C and D) and improved process efficiency and effectiveness (Organisations A, B and E). Cycle time reduction was also cited by respondents from Organisations D and E. Soft benefits mentioned included increased engagement between management and employees (Organisation B), increased awareness of CI practices among employees and increased employee efficiency (Organisations C and E). Thus, the overall ranking for the five benefits is as follows:

1- Reduced waste in the process.
2- Increased customer satisfaction.
3- Improved process efficiency and effectiveness.
4- Reduced cycle time.
5- Soft benefits such as changing staff mindset, increasing awareness of CI and creating engagement between management and employees.

The literature review identified the most commonly cited benefits of LSS as increased financial savings, increased customer satisfaction, reduced cost, reduced cycle time and improved key performance metrics. In other words, only two benefits appear in both the Saudi case studies and the literature: increased customer satisfaction and reduced cycle time.

Most interestingly, other benefits cited in the literature, such as increased profits and financial savings, and reduced cost, were rarely mentioned by the case organisations, suggesting that while Western organisations perceive bottom-line savings as one of the top benefits of implementing CI, this was not the main priority of any of the case organisations when deciding to deploy Lean or Six Sigma. Organisation D was the only case organisation to assume that Lean had brought financial benefits, while, although Organisation A had gained financial benefits in some projects, this was not rated in the top five benefits. This finding supports the survey results (see Chapter 4 section 4.2.3.7), which show that most of the participating organisations, especially those in the public sector, had opted to ignore the financial impacts of LSS or CI initiatives and focus more on non-financial impacts. However, if the organisation reduces waste and improves quality of any process over a long time, this should lead to reduced operational costs (Crosby, 1979).

Investment in Lean and Six Sigma in the case organisations was geared mainly towards building up human capital, that is, training employees and improving their CI skills. Only Organisations A and B were able to quantify their investment in Lean/Six Sigma, with A having spent $25 million to date and B spending $2 million per year. The return on investment from LSS should be at least 1:5 to 1:8 (Snee, 2004, 2010), but none of the case organisations felt this expectation should apply, since they were not using Lean and Six Sigma as cost-cutting methodologies. Instead, they chose to measure success in terms of improvements to quality, process efficiency and customer satisfaction. Since this last is particularly important to most of the case organisations, it is essential to understand how it is measured. All but one organisation (E) captured the views of both internal and external customers, while A and D also had dedicated customer complaint departments which collated customer feedback for conversion into projects by the quality department. The most common techniques for capturing customers' views in the case organisations were surveys and face-to-face interviews. Surprisingly, none were using the Kano model because none of the interviewees were familiar with this model and how or why it can be used, even though this is one of the most widely recognised models for analysing customers' needs (George et al., 2005).

Looking at the impact LSS across the range of business functions, this seems to have been greatest in Organisation A, most of whose business units had undergone at least one LSS project. This was followed by Organisation D, which had implemented Lean tools and techniques across the organisation as part of its own production system (full deployment). Organisation B had also implemented Lean all over the organisation, particularly in the maintenance and engineering departments, where all its Lean practitioners were currently working. Organisations C and E had only implemented initiatives in one department so far (partial deployment), but participants from both expressed the hope that this would be extended across the organisation.

6.3.4 Critical success factors (CSFs) for LSS

Training and education were cited as the top factor by all cases. In Organisations A, B, C and E, this was followed by top management support, commitment and involvement. The top five CSFs may be ranked as follows:

1- Training and education.
2- Top management commitment and support.
3- Project selection and prioritisation.
4- Communication.
5- Availability of resources.

The top three CSFs are identical to those identified in the literature (see Chapter 2 section 2.5.5.1) while the top two factors were very common across all cases.

The top five CSFs identified in the survey were then investigated further by means of a small additional survey distributed to 29 interviewees (refer to table C.2.1 in Appendix C.2). The purpose of this investigation was to identify whether there was a gap between the importance attributed to these five CSFs and actual practice in the participating organisations. The survey used a five-point Likert scale, where 1 indicated very low importance/very low practice and 5 indicated very high importance/very high practice. The Wilcoxon signed ranks non-parametric test, usually applied to the comparison of two dependent samples (Rey and Neuhäuser, 2011), was used to assess the significance of the gap between the mean scores for the importance of CSFs and those for their practice. This test was used in similar studies (Kumar, 2010; Lim, 2016). The results are presented in Table 6.2.

Table 6.2: Gap analysis of critical success factors for LSS

Critical success factors	Importance Mean	Practice Mean	Gap	Asymp. Sig. (2-tailed)
Top management commitment and support	4.90	3.85	1.05**	.001*
Training and education	4.85	3.60	1.25**	.001*
Availability of resources	4.60	3.00	1.6**	.001*
Communication	4.55	3.45	1.1**	.001*
Project selection and prioritisation	4.45	3.25	1.2**	.001*

*: The gap between the importance and practice is significant at $P < 1\%$
**: The gap between the importance and practice is significant at $P < 5\%$

Table 6.2 shows that the highest mean value for importance (4.90) was attributed to top management commitment and support, but that there was a gap of 1.05 between importance and practice for this factor. In other words, although considered essential to Lean/Six Sigma success, it was not widely practised. A similar picture emerges for all the other variables; all have a mean importance greater than 4 but a mean practice value below 4, indicating that although the participants rated these factors as the most critical success factors for LSS in their organisations, more needed to be done to bring performance in terms of these factors up to the required standard. In all cases, the gap between application and perceived importance is statistically significant. The gaps are statistically significant at both 1% significance level and 5% significance level because the value of $P < 1\% / 5\%$.

Table 6.3 gives some insight into how these findings compare with those of similar investigations conducted in six other countries (USA, Netherlands, UK, India, Malaysia and Australia) in terms of the rankings of the top five CSFs.

Table 6.3: The top five CSFs across different countries

CSFs	Saudi	USA	Netherlands	UK	India	Malaysia	Australia
Training and education	X	X	X	X	X	X	X
Communication	X	X	X	X		X	X
Top management commitment and involvement	X	X	X	X	X	X	X
Project selection and prioritisation	X	X	X			X	
Organisational culture		X	X		X		
Finding and understanding the problem correctly in the first place					X		
Employee engagement and their active involvement throughout the LSS deployment					X		
Availability of resources	X			X		X	X
Effective and efficient performance measurement and management system							X
Organisational infrastructure				X			

Training and education, and top management commitment and involvement are the most highly rated factors, followed by communication, project selection and prioritisation, and availability of resources.

6.3.5 Challenges for LSS implementation

Among interviewees, the most commonly cited challenge facing Lean and Six Sigma was resistance to change. Each of the case organisations reported at least one challenge related to changing the mindset of employees or managers. This echoes the findings of many other authors, as reported in the literature review (e.g. Antony et al., 2012; Bhasin and Burcher, 2006; Bhasin, 2011, 2012a, 2012b; Black and Revere, 2006; Burcheret al., 2011; Harrison and Storey, 1996; Kwak and Anbari, 2006). It is also aligned with the survey findings (see Chapter 4 section 4.2.3.11), which identify resistance to change as one of the top reasons why LSS projects fail (see Table 4.11 and Table A.5 in the Appendix A). The support of the process owner and the project sponsor are particularly crucial in this regard; they must be on board and allowed to have input, especially if they will be required to enforce change from the top down. The support of the project champion is also important to deal with the resistance to change, apart from the initial support of the project sponsor (Chakravorty, 2009).

Interviewees in Organisations A, B, C and E also cited the unavailability of data as an obstacle. Recording data seemed to be a low priority in the case organisations, although employees and managers were beginning to realise that accurate and comprehensive data must be made available if CI initiatives are to be successful. Accurate data are data that are free from error, complete, consistent and updated (Snee, 2004). It is important to have accurate data to analyse potential root causes, support the CI team's decisions (Antony and Banuelas, 2002), measure the current process (Hensley and Dobie, 2005) and measure the right outcomes that are important to analyse, improve, and control the process (Walters, 2005).

Another common challenge for Lean and Six Sigma in the case organisations was changing the organisational culture. This challenge was not cited as common either in the survey or the literature. However, this challenge appeared to be due to lack of leadership and lack of training (Antony and Kumar, 2012; Salah et al., 2010).

The case organisations, all of whom were employing a mix of nationalities, cited language barriers and poor communication as another challenge to LSS. This challenge was also cited by Albayoudh (2003) and Alrabeah et al. (2015) for TQM deployment in Saudi organisations. However, in this study, the private sector organisations had attempted to overcome the language problems by creating a supportive work environment for all employees and adopting the English language for all work transactions. In fact, English language proficiency has become a key requirement for Saudis wanting to work in private organisations. However, public sector organisations still suffer from language barriers, as English language proficiency is not a requirement.

Miscommunication between different departments, and with the quality department, can also hamper departmental efforts to implement CI initiatives. In these circumstances, it might be more effective to follow the example of some US companies and divide the quality department into small teams, distributing them across the business functions and making every member of the organisation responsible for quality (Dale et al., 2007; Folaron and Chase, 2003). The last challenge cited was losing LSS team members after they had received their training, which in some cases was due to weak LSS infrastructure.

According to the interviews, the five most commonly cited challenges to the implementation of Lean/Six Sigma were:

1- Resistance to change.
2- Unavailability of data.
3- Changing the culture.
4- Language barriers and poor communication.
5- Lack of manpower.

However, when the interviewees were surveyed (refer to table C.2.2 in Appendix C.2) to investigate the perceived seriousness of these challenges, a different ranking order emerged. Using the survey results from the second phase of the research (Chapter 4), the interviewees were asked to indicate on a five-point Likert scale (where 1 = strongly disagree and 5 = strongly agree) how significant a barrier they felt the identified challenges posed in their organisation as shown in table 6.4.

Table 6.4: The most serious challenges to LSS

Challenges	Mean
Lack of leadership	4.20
Time consuming	4.10
Lack of awareness of LSS benefits to the business	3.95
Convincing top management	3.65
Resistance to change	3.65

The mean values indicate that lack of leadership and being time consuming are perceived as the greatest challenges for LSS in the participating organisations. This finding slightly matches the results of the survey (Table 4.9) but the results are quite different from those reported in the literature by Richard (2008), Thomas et al. (2008, 2014) and Timans et al. (2012), for example.

6.3.6 Impact of organisational culture and leadership on LSS

The organisational culture has a crucial impact on any CI initiative. The findings from the interviews show that only Organisation A had a culture that is strongly supportive of LSS, and this was down to its visionary and committed leadership. The cultures of C, D and E were broadly, but not entirely, supportive, while the organisational culture of Organisation B, in which individuals did not feel any competitive pressure and did not understand the need for CI, had a negative impact on its efforts to implement Lean.

In all five organisations, it was reported that opinion was divided between those who support and those who resist change, and in all cases, the second group comprised older staff who had been working in the organisation for more than fifteen years. Changing the culture in these organisations will necessitate recruiting a new generation of employees and gradually replacing the old guard. This finding supports those researchers who argue that young professionals are more flexible than older staff and are more likely to see change as part of their job (Lattuch and Young, 2011). They also have the power to drive innovation throughout the culture (Agin and Gibson, 2010).

On the other hand, the respondents in the case organisations asserted that CI practices had significantly improved their organisational culture. Widespread training and involvement in Lean and Six Sigma projects had a very positive impact, changing employee's mindsets, so that they then went on to convince other employees to embark on the journey. As staff gain greater understanding of processes and learn new methods for problem solving, this leads to changes in how tasks are carried out. Furthermore, Lean and Six Sigma may also contribute to leadership development. This had already happened in Organisation A, while in Organisation B, Lean leaders had been sent to training programmes to improve their leadership skills. Similarly, Organisation D had introduced a new programme to improve leadership skills for LSS in leading operational and strategic projects and assignments; these included the ability to work at a higher level of responsibility, support staff involved in Lean and Six Sigma projects and many other skills.

In contrast, those in Organisations C and E felt that the leadership had not yet played any visible role in the development of LSS, and neither organisation had any programme in place to train leaders for LSS.

From the above and according to the literature (Albayoudh, 2003; Almuharib, 2014; Alsmadi et al., 2012), it is clear that organisational culture in Saudi Arabian organisations is a serious obstacle for any CI initiative to be successfully deployed. The organisational culture in Saudi Arabia is not supportive of CI in many ways. For example, employees are against change;

managers make decisions and give orders to their employees without involving them in decision making; an open door policy is not preferred; there is a fear of taking openly about mistakes and failure, and the blame culture is dominant (Albayoudh, 2003; Almuharib, 2014). On the other hand, Western organisational culture encourages the positive behaviours that support CI and influence creativity and innovation (Martins and Terblanche, 2003); nevertheless, changing the organisational culture is still a barrier for CI, even for organisations in Western countries (Antony and Kumar, 2012; Pepper and Spedding, 2010). However, it is possible to deploy CI initiatives and change the culture by making people understand the importance of the change. To do so, it is critical to understand the culture and its needs and have proper leadership in place (Albayoudh, 2003; Almuharib, 2014).

6.3.7 Successful and failed LSS projects and project selection

It was observed that the number of implemented projects across the cases was relatively low, given how long the organisations had been engaging in CI (see Figure 6.2). For example, although Organisation A had more than 100 BBs, each of whom was required to implement a minimum of two projects per year, it had only managed to conduct 150 Six Sigma projects in 12 years and 30 LSS projects in five years. Organisation B had 32 Lean practitioners, who had conducted around 50 Lean projects over three years (approximately sixteen projects per year). This gives a ratio of Lean practitioners to Lean projects of 2:1; that is, for every two practitioners, only one Lean project had been implemented per year.

Organisation C also had a shortfall in projects, with four BBs and one GB but only four Six Sigma projects completed in two years. Organisation D had completed a total of only 30 Lean and Six Sigma projects since 2004, but the focus in this organisation is more on its own production system than on Lean and Six Sigma. Organisation E had completed just one LSS pilot project since 2013, though more projects were planned. The slow start in E was attributed by the interviewee to the poor performance of the Lean and Six Sigma team and a lack of commitment from top management.

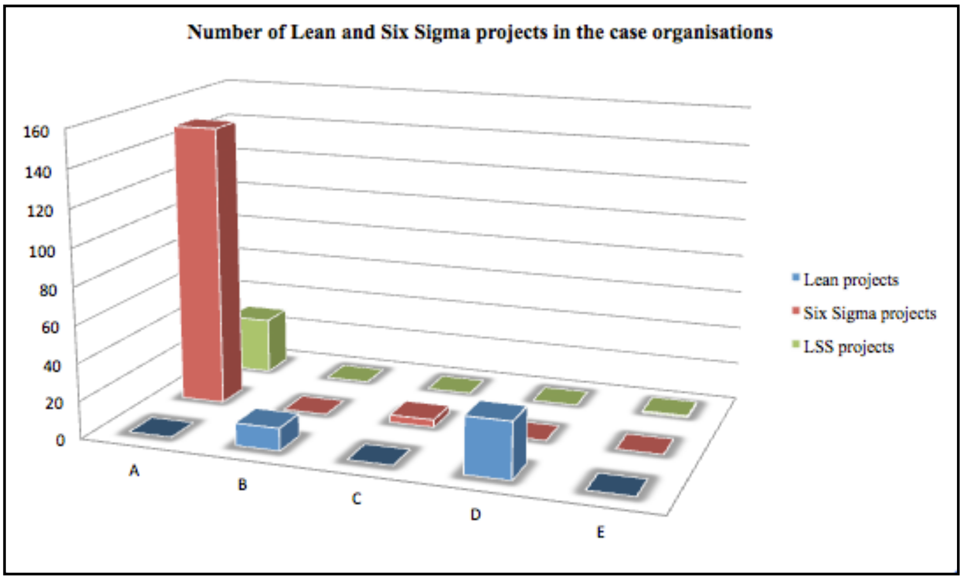


Figure 6.2: Number of Lean and Six Sigma projects in the case organisations

Figure 6.2 clearly shows that the overall number of completed projects by the case organisations was very low, compared to the cases reported in the literature. For instance, Akkerhuis et al., (2015) presented a case study in the business school at the University of Amsterdam showing that two years after LSS was introduced in the school there were 36 projects organised, of which 24 projects were implemented successfully. That means the average number of projects implemented in the school was 12 per year. Another case study by Wijma et al. (2009) in the nursing department in a university medical centre in the Netherlands showed that, in the first 18 months of LSS implementation, there were approximately 90 projects initiated. It is reported that a Lean practitioner can execute one Lean project every six weeks, making a total of eight projects per year from each Lean practitioner (Ballard and Howell, 2003). Therefore, the expected number of Lean projects in organisation B would be 256 projects per year.

It should be noted that it was very difficult to collect accurate data in regard to the number of failed projects in the participating organisations, and the reasons why they failed, as this data was rarely recorded. However, the interviewees from Organisations A, B and D suggested several reasons for project failure (see Table 5.4) including:

1- Lack of top management support, especially in the early stages of the implementation journey. Although this was ranked the top CSF for LSS by most of the participating organisations, support for the LSS team was initially very weak in Organisation A; it was not until tangible benefits were realised that the team got more support and commitment from managers.

2- The interviewee from Organisation A also cited senior managers' unreasonable expectations of BBs, explaining that there was a big gap between what senior managers wanted from BBs and what they could deliver. This point is cited in the literature as one of the main reasons for LSS project failure (Albliwi et al., 2014; Richard, 2008; Thomas et al., 2008; Timans et al., 2012).

3- Projects lack focus and are overambitious in scope.

4- The interviewee from Organisation B pointed to the danger of copying other organisations' strategies. This is also cited in the literature as one of the top reasons for Lean/Six Sigma failure (see Table A.5 in Appendix A) (AlAmin and Karim, 2013; Antony et al., 2012b; Bhasin, 2012a).

The fact that these reasons echo those identified in the literature indicates that Lean/Six Sigma project failure is not necessarily connected to country or culture. Finally, though not strictly failures, it was observed that projects were particularly slow in Organisations C and D (taking up to a year to complete). The interviewees argued that this was mainly due to the lack of data, as a consequence of which the 'Measure' phase of the project, during which data is collected, could take several months.

Investigation of the most commonly used criteria for selecting and prioritising Lean and Six Sigma projects indicated that, in Organisations A and B, priority was given to projects that would enhance process efficiency (in B, each department was asked to nominate one Lean focal point and prioritise its projects accordingly). Organisation D used customer feedback to prioritise its projects, in addition to selecting projects that addressed identified problems, especially on the shop floor. Organisations C and E prioritised projects that would help resolve their most chronic problems.

According to Antony (2011), CI initiatives and projects should be selected following a top-down approach; that is, improvement has to start from the top of the organisation's hierarchy and trickle down to the shop floor. In the case organisations, however, improvement was observed to start from whichever department was trained in CI, with staff in this department advising top management on what improvement was required and setting out the expected results. If the top management was interested, it might decide to expand the improvement through the organisation, send more people for training or seek the help of external consultants. The author argues that CI has to be top-management-led rather than department-led and if one department only is leading a CI initiative, this will flounder and fail to sustain the CI initiative (Antony, 2011; Snee, 2010). For instance, Six Sigma in successful companies such as GE, Motorola and Bank of America was initiated from their CEOs and not from middle managers or departmental heads (Antony, 2011; Bendell, 2005; Coronado and Antony, 2002; Snee, 2010).

6.3.8 Role of HR and IT departments in LSS

HR's role in regard to Lean and Six Sigma was recognised by all the case organisations, although not all of them received the required support from HR. For instance, the HR department played a major role in LSS in Organisations A and D, but its role was only minor in Organisation B and non-existent in Organisations C and E (both public sector, and both having plans for future collaboration). Arguably, there should be a greater focus on HR and more collaboration between HR and quality departments in terms of allocating people for training and rewarding LSS team members for project success. This is because human resource management has a significant impact on quality performance (Shah et al., 2008). Antony and Banuelas (2002), Fazzari and Levitt (2008), It is pointed out by Salah et al. (2010) and Zu et al. (2008) that HR has an important role in arranging for employee education, training and workshops, employee involvement in decisions, team work to solve problems, employee recognition and reward for their contribution in making improvement, employee engagement and commitment and job satisfaction. These activities provided by the HR department will maintain a high-performance work environment and hence promote organisational success.

IT departments played no role in regard to Lean/Six Sigma, apart from in Organisation A, where this department played a minor role in a very limited number of projects. It seems that in these case organisations there was a lack of communication or a lack of understanding regarding the potential impact IT departments can have on LSS project success. This can be compared to the literature, where it is emphasised that the contribution of the IT department is necessary to track Six Sigma projects and enhance the applicability of LSS (Antony, 2012; Sehwail and DeYong, 2003). As the main objective of an IT department is to facilitate business processes throughout the organisation (Svensson et al., 2015), IT experts can work with the LSS team to support the process (Anand et al., 2010), and also to streamline the processes, and eliminate redundant data entry (Furterer and Elshennawy, 2005).

6.4 Motivating factors for LSS implementation (RQ2)

It was found that the most common motivating factors for deploying Lean/Six Sigma in the case organisations were:

1-To reduce/remove waste in the process by eliminating NVA activities.

2-To improve process efficiency and effectiveness.

3-To increase customer satisfaction.

4-To improve quality of outputs.

5-To make financial savings to the bottom-line.

Several of these factors (increase customer satisfaction, improve quality and improve the bottom-line) are repeatedly cited in the literature as common motivations for LSS. However, an additional motivating factor emerged in this study, which may be common in organisations in Saudi Arabia, that is, pressure from joint venture partners (A and B) or foreign parent organisations (D, which had been obliged to implement first Lean and subsequently Six Sigma by its French parent company).

Comparison of the case organisations' motivations for deploying LSS and the benefits gained shows that Lean, Six Sigma or LSS had been introduced to achieve specific goals, and that on the whole, these goals had been achieved. Thus, Organisation A had been successful in achieving its stated aims of reducing waste in the process, becoming process-oriented and increasing customer satisfaction. Organisation C, on the other hand, had not yet managed to meet its primary target of using LSS to build a culture of quality. In fact, this goal may only be achieved in the long-term, by executing more projects and delivering training for more people across the organisation.

To put these findings into context, it is necessary to compare the motivating factors identified in Saudi Arabia with those identified in other countries that have been implementing LSS for a while. The USA, UK, Netherlands, India and China were chosen for comparison, as they are all well represented in the LSS literature. Table 6.5 shows the most common motivational factors in each country.

Table 6.5: The most common motivational factors for LSS across different countries

Motivational factors	Saudi	USA	Netherlands	UK	India	China
To reduce/remove waste in the process by eliminating NVA activities	X	X	X	X	X	X
To improve process efficiency and effectiveness	X	X	X			
To increase customer satisfaction	X	X	X	X	X	X
To improve quality of outputs	X	X	X	X	X	X
To make financial savings to the bottom-line/increase revenue	X	X	X	X	X	X
To reduce production/service cost		X	X	X	X	X
To reduce cycle time/wait time	X	X	X	X		
To increase production capacity		X	X			
To reduce defects in the process	X	X		X	X	X

To change /establish the competitive position in the market	X	X	X
To assess the effectiveness of LSS in a specific industry		X	X

From the table above, it can be observed that reducing/removing waste in the process by eliminating NVA activities, increasing customer satisfaction, improving the quality of outputs, and making financial savings to the bottom-line/increasing revenue are the top motivations across all countries. The table also shows that Western countries were motivated to deploy LSS to change /establish the competitive position in the market, whereas this factor did not appear in Eastern countries. This could be due to lack of awareness regarding LSS benefits in business, which is one of the top challenges facing businesses (Kumar et al., 2006; Snee, 2010; Thomas et al., 2008). However, Snee (2010) suggests that this can be tackled through training and education, as well as by learning lessons from previous success stories of other organisations.

The factors that motivate employees to get involved in LSS training and projects, to become a LSS team member, or to use LSS as a process improvement strategy were explored during the interviews. The results show that employees were primarily self-motivated, driven by a desire to learn a new method that would help improve how they work and enhance their employability.

The interviewees stated that people and organisations in Saudi Arabia know very little about CI; the Saudi market has only recently started to explore LSS, but while Lean is more widely recognised, little is known of Six Sigma. With the third party sector placing great emphasis on LSS and universities starting to teach LSS as part of their quality courses, there is a growing need for individuals with LSS experience. This is therefore a good time to focus on self-development and building experience in the new methodologies – experience which might lead to a bright future as a consultant in one of Saudi Arabia’s large corporations. More generally, several interviewees were motivated to become involved in LSS because they saw it as a way of enhancing their résumé by developing their teamwork, problem solving, leadership and project management skills. Others explained that they enjoyed seeing projects succeed and being able to make a difference, and the chance to be creative and put more into their job. Interestingly, none of the interviewees was motivated by the prospect of financial benefits, although this may be because few of the case organisations had a recognised system in place to reward LSS team members for their achievements of successful Lean/Six Sigma projects.

6.5 Organisational learning (RQ4)

In the survey, participants were asked to rate the extent to which their organisation encouraged them to learn from others' experiences, from errors during project implementation, from failed LSS projects or any other source (see Chapter 4). In the interview phase, the interviewees were asked to explain more about how the learning practices in their organisation supported LSS deployment. The most common organisational learning practices in the case organisations were:

1- Sharing knowledge and experience of LSS deployment via databases, knowledge networks, regular meetings, communication boards, daily e-mails, presentations, open discussions and reports.
2- Learning from failure, mistakes and incidents.
3- Learning from the joint venture organisation, parent organisation, and the organisation's own production system.

It was observed that Organisation A ran far more learning activities than the other organisations in this study. This was mainly due to its US joint venture partner, which had provided A with their own production system framework and a knowledge network to support learning. Organisation D had also reached a good level in terms of learning practices, in this case, with the guidance of its parent organisation. D's own production system included a range of learning activities (see Chapter 5). Organisation B lagged behind A and D in that it did not yet have the mechanisms in place to allow employees to learn from their own and others' mistakes or to share knowledge, although it had adopted a few learning practices from its joint venture partners. Finally, Organisations C and E (public organisations) were far behind the other case organisations in terms of organisational learning practices, even though they both had trained LSS teams/quality teams who were fully aware of the importance of these practices. The respondents from both C and E insisted that organisational learning would improve in the near future, in parallel with LSS implementation. This implies that Saudi public organisations do not foster organisational learning and they do not have the culture of learning from mistakes and failure. This was due to certain inhibitors, such as lack of encouragement for employees to reflect on their experience and share their opinions regarding projects, a fear of sharing mistakes openly, and lack of benchmarking with other organisations in the business, due to lack of collaboration among organisations. This clearly shows the dominant Saudi culture in public organisations, which is very different from that in other organisations, where their parent companies are located in either the USA or Europe.

In general, the organisational learning practices reported by the interviewees were very

simple and basic compared to the wide range of practices suggested in the literature. Learning practice within the case organisations seemed to be mainly socially oriented, with the focus being on sharing and reflection (Savolainen and Haikonen, 2007). It was also primarily local (i.e. occurring within the team/organisation) (Arumugam et al., 2013), although there was some distance learning in the private sector organisations (A, B and D), courtesy of their partner organisations (however, this too was very basic). Organisation D was implementing experimental learning, using the learning by doing technique (Arumugam et al., 2013).
This suggests that some very important opportunities for learning are being ignored here. For instance, none of the organisations had considered the PDCA cycle as a source of learning under LSS, as suggested by scholars such as Savolainen and Haikonen (2007) and Arumugam et al. (2013). In addition, too little attention was being paid to technically-oriented learning using measurements and learning curves (Savolainen and Haikonen, 2007). The literature recommends using the LSS team to transfer knowledge (Arumugam et al., 2013); this could be readily done in Organisations A, C and E, all of which have either a Six Sigma department or a LSS team based in the quality department. These staff carry their skills and knowledge with them whenever they are assigned to a new project or a new part of the organisation (Arumugam et al., 2013; Hoerl, 2001).

In order to gain further insight into the key factors affecting organisational learning in the case organisations, 29 interviewees were asked to fill out a small survey (see table C.2.3 in Appendix C.2). This listed a number of organisational learning factors identified in the literature (Garvin et al., 2008; Hines et al., 2004; Manville et al., 2012; Savolainen and Haikonen, 2007; Schroeder et al., 2008; Watson, 2001). Interviewees were asked to mark on a five-point Likert scale (where 1 = very low importance/very low practice and 5 = very high importance/very high practice) how important they perceived each factor to be in facilitating organisational learning, and how evident these factors were in their organisation. The Wilcoxon signed ranks non-parametric test, usually applied to the comparison of two dependent samples (Rey and Neuhäuser, 2011), was used to assess the significance of the gap between the perceived importance and actual practice of these organisational learning factors in the participating organisations, and the extent to which the factors were practically applicable (see Table 6.6).

Table 6.6: Gap analysis of organisational learning practices

Organisational learning factors		Importance mean	Practice mean	Gap	Asymp. Sig. (2-tailed)
Supportive learning environment	1-Psychological safety e.g. sharing information and problems, easy to speak and share what is in your mind	4.65	3.50	1.15**	.001*
	2-Appreciation of differences in opinions	4.35	3.40	0.95**	.001*
	3-Openness to new ideas e.g. new ideas are welcome, interest in better ways of doing things	4.70	3.40	1.30**	.000*
	4-Time for reflection and reviewing how the work is going	4.45	3.00	1.45**	.001*
Concrete learning process and practices	1-Experimentation e.g. new ways of working, offering new products/services and dealing with new ideas	4.25	3.15	1.10**	.001*
	2-Information collection e.g. about competitors, customers, technology trends and comparing to the market	4.20	3.20	1.00**	.002*
	3-Analysis to identify and solve problems	4.65	3.55	1.10**	.001*
	4-Education and training	4.60	3.35	1.25**	.000*
	5-Information transfer e.g. meetings with other departments, external experts and customers	4.60	3.50	1.10**	.001*
Leadership that reinforces learning	1-Good listener	4.80	3.50	1.30**	.000*
	2-Encourages multiple points of view	4.55	3.30	1.25**	.000*
	3-Invites input from others	4.50	3.25	1.25**	.000*
	4-Acknowledges his own limitations	4.35	2.70	1.65**	.000*

*: The gap between the importance and practice is significant at P < 1% or .01
**: The gap between the importance and practice is significant at P < 5% or .05

Table 6.6 shows that each of the organisational learning factors has an importance mean greater than 4, indicating that a high level of importance is attached to all of them. However, mean practice values of less than 4 across the board suggest that this perceived importance is not reflected in practice. The findings show that having leaders who are good listeners, and a culture that is open to new ideas were considered the most important factors, while information collection and experimentation were seen as the least important. The analysis indicates that the gap between application and perceived importance is statistically significant for all factors; the fact that this gap is still huge for most of the factors means that the level of organisational learning is likely to be affected.

Although interviewees reported that they were undertaking some organisational learning practices, the scores in Table 6.6 show that there was still more to be improved in regard to learning behaviours. This indicates that interviewees were only aware of and implementing a very few and basic organisational learning practices, while they were not familiar with the other practices presented in Table 6.6.

6.6 Comparing LSS practices and status in the public and private sectors

As the study included two organisations from the public sector and three from the private sector, it was important to investigate whether there are any conspicuous differences between the two clusters across the key themes. Accordingly, Table 6.7 summarises the key points of comparison and contrast in terms of the themes discussed in previous sections.

Table 6.7: Comparison of LSS practice in public and private case organisations

LSS practice	Public sector (Organisations C and E)	Private sector (Organisations A, B and D)	Observation
Years of deploying LSS, infrastructure and training for LSS and level of LSS awareness	-Six Sigma and LSS recently introduced -Infrastructure was very weak: only 5 or 6 team members - Few employees were trained by an external body -LSS awareness level was very low but growing with training	-Between 2 and 12 years -Infrastructure in A was very advanced but in B and D was very weak and below requirement (refer to Table 2.1) -B and D offered training with external companies -LSS awareness level was high in A; it was moderate in B and D but growing with training	Private sector organisations were more advanced than public sector, but B and D were still relatively weak in their infrastructure and training
LSS methodologies, tools and techniques	-Very simple and basic tools and techniques under DMAIC -Most of the tools were from Lean toolbox because they are simple, easy to apply and straightforward	-Very simple and basic tools and techniques under DMAIC -Most of the tools were from Lean toolbox because they are simple, easy to apply and straightforward	Very similar
Benefits gained from LSS and its impact on business functions	Most of the gained benefits were soft; very few hard benefits	Most of the gained benefits were soft; very few hard benefits	Very similar
Critical Success Factors (CSFs) for LSS	Mainly related to top management commitment and training	Mainly related to top management commitment and training	Very similar
Challenges for LSS implementation	Most commonly cited challenges were human-	Most commonly cited challenges related to	Very similar

	related rather than technical, e.g. culture, change management and unavailability of data	change management, culture change and unavailability of data	
Impact of organisational culture and leadership on LSS	-Organisational culture was somewhat positive (refer to table 5.8) but still needed further improvement -The role of leadership was not observable yet in regard to CI practices	-Organisational culture varied between strongly positive in A and somewhat negative in B (refer to Table 5.8) and still need to be improved -The role of leadership was not observable yet in regard to CI practices in B and D, but in A, leaders were supportive and visionary	Organisational culture in A was good and supportive for LSS but the rest of the organisations still needed to improve their culture Leadership role was not observable yet in either sector, except for in Organisation A
Successful and failed LSS projects and project selection	-Very few successful projects -No failed projects -Project selection based on potential to solve perceived problems	-Number of successful projects was between 30 and 150 but still very low for the number of years LSS had been running -Very few projects have failed; data rarely recorded about failure -Project selection based on potential to improve process efficiency	Private sector had more successful projects, but both sectors had conducted fewer projects than might be expected. Both sectors had basic criteria for project selection
Role of HR and IT departments in LSS	No role	Major HR role minor IT role	Private sector progressing better than public sector
Motivational factors for LSS deployment	Most commonly cited factors were to remove waste and increase process efficiency, plus soft factors	Most commonly cited factors were to remove waste and increase process efficiency, plus soft factors	Very similar
Organisational learning in the context of LSS	Limited and basic learning practices in E; C had no learning practices in place yet	Learning from the joint venture organisation/ parent organisation, plus very basic learning practices	Both sectors had few and basic learning practices, but private sector learned from other organisations

Table 6.7 shows that the two sectors were very similar in terms of the implementation process and Lean/Six Sigma practice. Organisations in both sectors were using very basic LSS tools and had gained similar benefits; both cited top management commitment and training as CSFs and both found culture change, management change and data unavailability to be the main challenges. Organisational culture was a barrier for Lean and Six Sigma in both sectors due to the struggle to overcome the resistance of employees to changing the way

of doing work, although it was not yet clear what role the leadership was playing in fostering LSS in either sector (apart from in Organisation A). Organisations in both sectors were applying fairly basic criteria for selecting and prioritising projects, focusing on solving chronic problems with no solutions delivered in the past and improving process efficiency. Indeed, the main motivating factor in both sectors was the desire to remove waste and increase process efficiency, although they were also driven by soft factors such as the desire to enhance customer satisfaction.

Differences emerge in other areas, however; for example, the infrastructure and training in the private sector organisation were more advanced than in the public sector, notwithstanding the weaknesses that still existed in B and D.

In terms of the other themes, there are only minor differences. Thus, while the private sector companies had carried out more successful projects, in general, the number of projects in both sectors was below what might be expected. Similarly, the HR and IT departments were playing a slightly more substantial role in LSS deployment in the private sector, but only in some organisations. Finally, even though the private sector organisations had learning input from their joint venture partners/parent organisation, organisational learning practices remained basic in both sectors.

The interviewees acknowledged that LSS is still in the early stages of development in Saudi Arabia, especially in SMEs and national/public organisations. Only a few organisations are practising LSS, and most of these are multinationals such as GE, Bechtel, IBM and Xerox. Those large Saudi organisations that are implementing LSS are doing so because they have parent organisations in Western countries or international joint venture partners who are pushing them to adopt LSS to conform to global expectations. This seems to be confirmed by this study's finding that LSS was introduced much earlier in the multinational (Organisation D) and the joint ventures with multinationals (Organisations A and B) than in the public organisations (C and E). As a result, their awareness of CI initiatives was found to be greater than in the two public organisations, each of which had just five or six people trained in LSS at the time of the study.

Whatever the type of organisation, or however advanced their LSS journey, all the case organisations had found resistance to change to be their main challenge. The main source of this resistance was perceived to be long-term employees who had been working in the organisation, sometimes in the same position, for many years. These people were struggling to understand the potential benefits LSS might bring to their organisation, instead seeing it as a fad introduced by a new generation who lacked work experience. On the positive side, however, there was a high level of support and commitment from top management in all the case organisations, and in some (Organisation A), the organisations' owners were also very supportive.

6.7 Cross-comparison of the qualitative and quantitative findings

Chapter 4 identified a number of issues which could not be addressed by means of the survey technique. The aim of this section is to show how these issues were explored in the case studies.

1- The survey was unable to explore in detail how the financial benefits derived from LSS were measured in the case organisations, because the organisations had no mechanism in place for measuring financial benefits from LSS. However, in the interviews it emerged that success is in fact measured in terms of improvements to quality, process efficiency and customer satisfaction, rather than in terms of financial savings, which were at the bottom of the list for most of the organisations, particularly those in the public sector. However, investing in quality will lead to a reduction in problems such as rework, customer complaints and scrap, which in term will save the company a great deal of money.

2- Lack of training has resulted in weak LSS infrastructure in most Saudi organisations. Interviewees from all the case organisations agreed that they need to improve their infrastructure if Lean/Six Sigma is to work in the long-term. However, the interviews also revealed that none of the case organisations had employed local training institutions. This implies that perhaps Saudi companies do not trust local consultants and, moreover, that they think local consultancy companies do not deliver world-class training to companies. This means there is a shortage of skills in the local market and this is a gap which needs to be explored further, in terms of how to develop world-class training courses locally, rather than relying on Western consultancy and training providers.

3- The survey highlighted the relatively low number of completed projects, but the case studies suggest a number of possible reasons for this, including a lack of full-time BBs, weak LSS infrastructure, weak project selection and prioritisation criteria, and organisations having other priorities than LSS. For instance, A was preoccupied with its ERP project, B with their own production system, C with academic accreditation and E with restructuring the organisation, including the quality department.

4- The survey did not seek to identify what motivates individuals to become involved in

LSS projects. When this was investigated in the interviews, it became apparent that motivation is overwhelmingly intrinsic, with employees seeing their involvement as an opportunity for professional self-development (see section 6.4).

5- It became evident in the interviews that some organisations with little awareness of LSS nevertheless have GBs and BBs amongst their employees. This is most evident in the public sector organisations, who saw it as a way of creating awareness of and support for the deployment of LSS. Organisations C and E had each employed five or six trained staff, including MBB (in E), BBs and GBs, as a starting point for their LSS journey. The expectation is that these people will be able to execute projects and assume responsibility for training other employees across the organisation in the near future.

6- The survey did not address what happens when LSS team members leave the organisation that sponsored their LSS training, and how much this costs organisations. The case study shows that Organisation A had managed to retain employees and recoup its training expenses by asking BBs to work full-time for two years and to execute at least two projects per year. If they decided to leave within this time, they were expected to pay back the cost of their training. This also applied to YBs, GBs, BBs and MBBs. Other organisations in this study had no policy to retain trained staff, which cost these organisations a massive loss, especially when Six Sigma stopped in 2008 in organisations B and D. According to the literature, there are many reasons that lead qualified staff to leave the organisation, such as lack of employee engagement and involvement, and lack of career development e.g. lack of reward, lack of awards, lack of workshops and training, and lack of promotion (Davis, 2015; Devi, 2009). Hence, in order to retain employees in any business, it is important to create a plan for employees' career development, raise employee morale, and keep the employee feeling valuable, motivated and engaged (Davis, 2015; Devi, 2009).

6.8 Critical differences between LSS practices in Saudi Arabia and the literature

Table 6.8 presents the key findings of LSS practices in Saudi organisations and compares them to the findings and recommendations in the literature.

Table 6.8: Critical differences between LSS practices in Saudi Arabia and the literature

LSS Practices	Saudi Arabia	Literature
Training	-Most of the organisations were relying on Western consultancy and training providers, although there are local training providers in Saudi Arabia - There was no specific amount of saving to be certified for GB and BB -Certified BBs and GBs were not asked to execute projects after certification but they were involved in projects from time to time to solve problems	-The LSS training programme depends on the organisation, and most of the large organisations have created their own titles, training programmes and internal certification systems (Taghizadegan, 2006) -GB needs to execute 2 projects a year with $25,000 to $50,000 savings per project (Harry, 1998; Laureani and Antony, 2012; Snee, 2010). -BBs need to work full-time in BB projects and add $1million to annual profits (George, 2003; Harry, 1998; Harry et al., 2010; Hoerl, 2001; Snee, 2004; Taghizadegan, 2006)
Infrastructure	Infrastructure was very weak in most of the participating organisations. It was normal for organisations to not have Champions or MBBs, while the BBs carried most of the responsibilities. However, there were plans for further improvement	It is recommended that organisations need 1 YB for every 5 employees, 5 GBs for every 100 employees, 1 BB for every 100 employees and 1 MBB for every 15-20 BBs, while the position of champion is very important for the success of LSS, for successful integration of LSS into the business and to maintain financial benefits in the long-term (Breyfogle, 2003; George, 2003; Harry, 1998; Laureani and Antony, 2012; Voehl et al., 2013)
Project selection	No criteria for project selection and priority was given to projects that would enhance process efficiency, use customer feedback to prioritise projects, and to selecting projects that would help resolve their most chronic problems	The most appropriate project is the one with the most potential benefits to the bottom-line (Snee, 2010), creating value for customers and fitting in with available resources and schedule (Zinkgraf and Snee, 1999).
Financial benefits	Measuring financial benefits from LSS projects was not the main focus for most of the participating organisations	Measuring the success of LSS is defined by financial saving to the bottom-line, reducing defects, waste, scrap, and rework, together with improving processes and output quality, and increasing the satisfaction of customers, employees and stakeholders (Snee, 2010)
Organisational learning	Very simple learning practices were available within LSS projects and single-loop learning was much applied, where the same problem might occur several times	'Learns how to undertake the experiment better the next time', is the level needed for complete implementation of LSS (Hines et al., 2004)
Motivation factors	The dominant motivation factors were to improve quality, reduce waste, improve efficiency and customer satisfaction while increasing financial benefits was not the top motivation for most of the participating organisations	Make saving, increase the bottom-line, reduce cost and enhance revenue are the main motivation for companies to deploy LSS (Smith, 2003; Snee, 2010; Snee et al., 2002)

The LSS practices in Saudi organisations presented in Table 6.8 were completely against the recommendations of the literature. Many weaknesses were reported in the table that needed further improvement to reach the expected level suggested in the literature.

6.9 Chapter summary

This chapter has focused on research questions 1, 2 and 4, drawing on the themes identified in Chapters 4 and 5 and employing cross-case analysis to identify similarities, differences and patterns among cases. The case study findings have also been used to provide further insight into some of the findings from the survey.

The case organisations and interviewees, although highly motivated, faced challenges in getting LSS off the ground, especially in the public sector, where the level of bureaucracy is very high and CI experience is very low. Saudi organisations are a long way behind their Western counterparts in the journey to build a strong CI culture; such a culture requires a high level of CI awareness across the organisation, strong leadership skills, sufficient infrastructure, continuous training and development for employees and managers, advanced tools and techniques, project selection criteria, clear expectations regarding the number of ongoing projects, mechanisms for measuring financial benefits, the continuous recording of data, a reward and recognition system for LSS team members and the support of other departments such as IT, HR and finance. Since Saudi organisations need to be able to assess where they are on this journey, and where they need to go next, the next chapter focuses on the development of a LSS maturity model (research question 3). The purpose of the model is to support Saudi organisations in assessing the maturity level of their LSS deployment and identifying opportunities for improvement.

CHAPTER SEVEN

Lean Six Sigma Maturity Model for Saudi Arabian Organisations

7.1 Introduction

This chapter presents the LSS maturity model (LSSMM) developed based on the systematic review of existing maturity models for business process excellence and LSS (Chapter 2) and the empirical studies reported in Chapters 5 and 6. This model aims to provide a clear and practical method of measurement for the current level of Lean Six Sigma maturity, particularly for Saudi organisations. The next section outlines the processes involved in developing and validating the model and provides an in-depth explanation of the main maturity levels, categories and the scoring criteria derived from the systematic literature review and the empirical research. A SWOT analysis is also undertaken to identify the internal strengths and weaknesses of the model, as well as the external opportunities and threats.

7.2 The process of developing the Lean Six Sigma maturity model (LSSMM)

Developing the LSSMM is the fourth phase of the research as shown earlier in figure 3.2. There are a number of processes to be followed for the development of an effective maturity model (García-Mireles et al., 2012; Röglinger et al., 2012; Wendler, 2012). These have been adopted and modified to build the desired model, as described in Figure 7.1. The processes followed in this study were:

- First, based on the review of the available models in the literature and practitioners' maturity models (unpublished) from companies who have employed LSS for over 20 years, the author identified the main previous research in the area of maturity models in general and of quality/operations-management-oriented studies in particular.
- Secondly, the targeted users of the model (employees using LSS in Saudi organisations) in the 5 case organisations in Saudi Arabia (the same organisations used previously in Chapters 5 and 6) were interviewed for further suggestions about the main components of the model, based on their experience of working in LSS in Saudi Arabia.
- Thirdly, the model was developed in terms of activities or constituent behaviours, characteristics in each level, categories, and a scoring system.

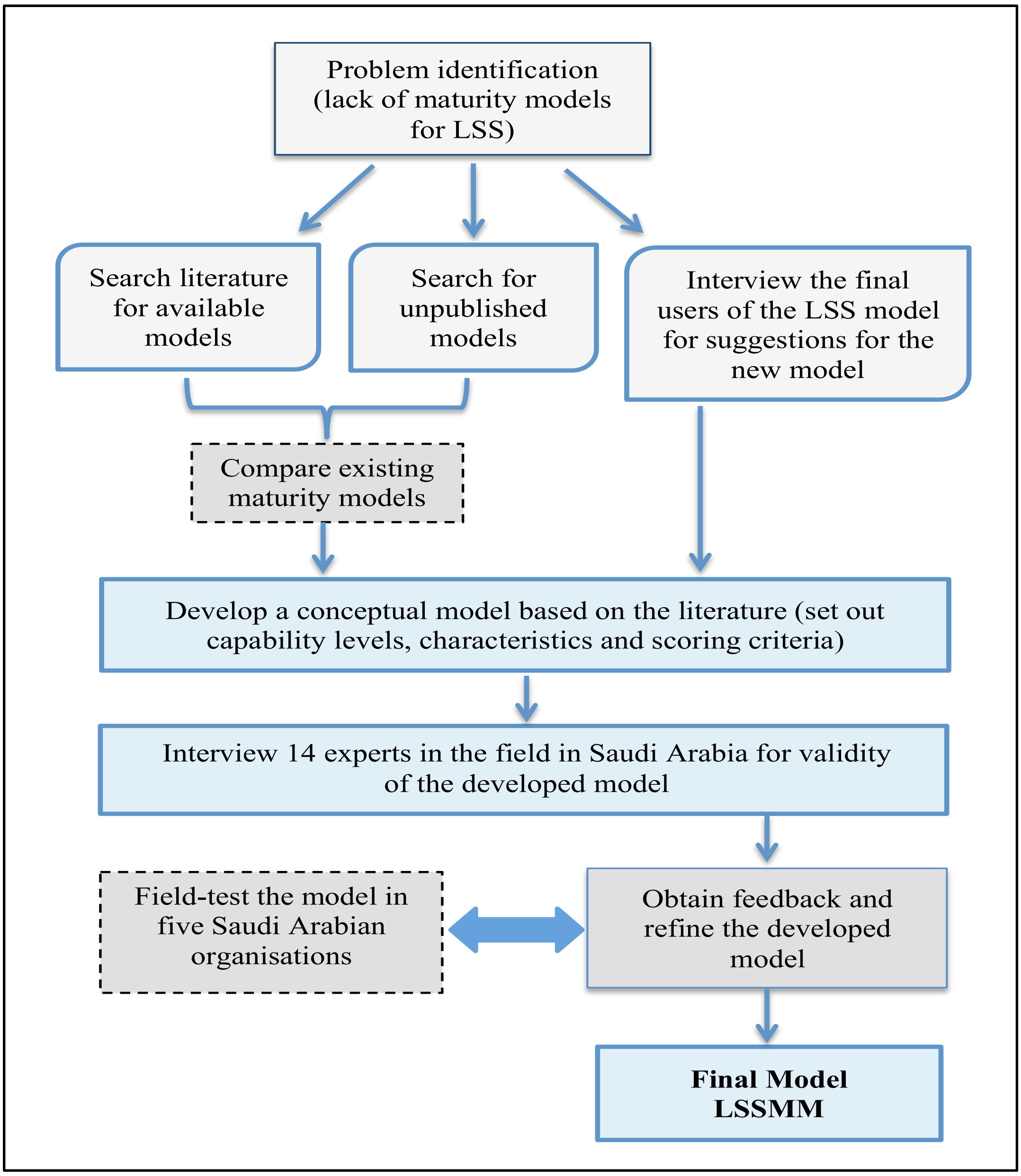


Figure 7.1: The process of developing the LSSMM

- Fourthly, to maximise the relevance and practical applicability of the proposed maturity model, a number of Lean Six Sigma experts were involved from the early stages of the development of the LSSMM artefacts, and also during the data collection process, and after the model was developed. In addition, 14 LSS experts working in Saudi organisations, including consultants, academics and practitioners, were called upon to validate the artefacts and their feedback was used for further improvement.
- Finally, the model was field-tested in 5 Saudi Arabian organisations, to measure their level of LSS maturity.

7.3 Maturity Models used for Lean/Six Sigma assessment in the case organisations in Saudi Arabia

In order to develop an effective maturity model that is customised for Saudi organisations, it was essential to investigate the available models in the case organisations. The interviewees were asked if they were using any maturity models for LSS (Table 7.1).

Table 7.1 shows that only two case organisations out of five were using models to measure the maturity of Lean/ Six Sigma. It was observed that these organisations were not familiar with the concept of maturity models, due to the lack of the available models for LSS. This indicated the need for such a model to help these organisations to assess their level of maturity and develop a future plan for sustainability of LSS.

The participants were then asked to share their thoughts and suggestions about the most important components that they thought were important to be considered in the new model. These suggestions are presented in table 7.1 and used to develop the LSS maturity model, including activities and categories.

Table 7.1: Summary of the available maturity models in the case organisations

	A	B	C	D	E
Maturity model used	None	Simple model with 5 levels	None	The organisation's own production system	None
Components of the suggested model for LSS	-Years of implementation -Infrastructure and training -Achievements -Project selection -Financial growth -Culture change -Human aspects	-Benchmark -Top management commitment -Awareness of value adding activities -Training and education - Strategic alignment -Handling waste	-Top management commitment -Awareness and training -Motivation and reward	-Management commitment -Strategic alignment -Leadership -Financial growth from year to year	-Quality -Customer satisfaction -Project selection and prioritisation criteria - Changing people's mind-sets -Using resources to the fullest

Organisation A was not using a rigorous maturity model to measure the level of LSS maturity in the organisation, although Six Sigma had been deployed in the organisation for 10 years and Lean for five years. The organisation strongly believed that LSS implementation was very mature in the organisation, based on the following indicators:

1- Years of implementation: Six Sigma had been implemented for more than 10 years and Lean for about five years.
2- Trained people: more than 100 BBs and 400 GBs had been trained.
3- Achievements: Caterpillar took the organisation as a benchmark, due to its high achievement in certain LSS projects.
4- Project selection: Projects were selected based on a set of criteria using a project selection matrix and with involvement of LSS champions in this exercise.
5- Financial growth: the percentage of financial growth from year to year (due to data confidentiality, the LSS champion did not agree to share the exact figures)
6- Culture: LSS tools and methods had become a way for working within the organisation.

To develop an effective maturity model for LSS, the interviewees recommended that all the above components should be in the model, plus people empowerment, which is crucial. The champion argued that the biggest asset of the company is the people. Thus, if the employees are empowered, then it will be easier for the company to embark on further CI practices.

Organisation B was using a maturity model that was introduced in 2012 to assess the level of Lean deployment. The model consists of five levels of maturity. The first stage is ‘costs are fixed’, second stage is cost consciousness and the recognition of the need to do something about the cost. The third stage is ‘waste elimination’, in which the focus is to move away from cost and think in terms of waste elimination. The fourth stage is ‘process culture’, where the aim is to start becoming a process culture, where everything is driven by processes and processes reveal where the areas of waste are. The final stage is called ‘Lean culture’, which is to be a learning and adaptive organisation. According to this model, the organisation was at that point at level 2, with some traces of level 3. The organisation was familiar with other maturity models and applying them for reliability and safety, but these were not related to Lean.

To develop an effective maturity model for LSS, the Lean champion and others stated that the model should measure financial return, benchmark achievement, top management commitment, awareness of value-adding activities, training and education, strategic alignment, employees’ engagement and waste handling. The champion argued that using a maturity model for Lean would make perfect sense, because measuring the maturity would result in the ability to reinforce either leadership or training, and knowing which components to work on.

Organisation C was not using any model for Six Sigma maturity at the time of the interview. However, the interviewees agreed with the importance of a maturity model to assess the level of implementation. They suggested that the key components to indicate the maturity level would be top management commitment, awareness and training, and motivation and reward.

Organisation D was using the organisation's own production system created by their parent organisation in France. The most important element to measure LSS in this model is leadership and employees' behaviours, whereas financial benefits are not a major element. This system has 40 principles, 33 activities under the principles and five levels in each activity. The levels are: basic, notion, standard, advanced and expert. The model has a scoring system of 1200 points and in the last assessment, in early 2015, organisation D had scored 120 points out of 1200, which is very low, locating the organisation within the first maturity level, which is basic. This assessment was conducted by a group of people who were assigned by the parent organisation in France.
To develop an effective maturity model for LSS, the interviewees suggested that the maturity model should place more focus on management commitment, leadership, strategic alignment of LSS projects to the main goals of the organisation, and financial growth from year to year.

In Organisation E, a maturity model was not being used, because the LSS initiative had been adopted only recently. However, the interviewees suggested that the LSS maturity model should be focused on quality, customer satisfaction, project selection and prioritisation criteria, changing people's mind-sets and using the resources to the fullest, whereas measuring financial saving is not a priority for public sector organisations.
Based on the review of the available models in the literature and the suggestions and recommendations of the interviewees, the most common components/categories were found to be:

1- Infrastructure and training.
2- Top management commitment and leadership.
3- Strategic alignment.
4- Project selection and prioritisation.

5- Motivation and recognition.

6- Financial benefits (ROI).

The seventh category, tools and techniques, was added later, based on the suggestions of some LSS experts who were involved in the process of testing the model, as shown in Table 7.2.

Some of these categories, such as top management commitment, leadership, training and education and project selection and prioritisation, were cited as top CSFs for LSS in Saudi organisations in Chapters 4, 5 and 6. Using the CSFs in developing the model provides the model with more precision and practicality (Shere, 2003; Zhen, 2009).

7.4 The development and pilot testing of the conceptual LSSMM

Based on the literature review of the maturity models (Chapter 2) and the interviews with the final users of the model (presented in Table 7.1), the author was able to develop a conceptual maturity model. However, in order to maximise the relevance, practical applicability and validity of the proposed maturity model, 14 LSS experts were called upon to validate the model. This group included consultants, academics and practitioners in Lean and Six Sigma in Saudi Arabia, comprising three LSS/Lean consultants, two Champions, four MBBs and five BBs. They were asked to go through the model and evaluate every aspect in the model and give their feedback for each maturity category and each activity and recommend whether each item should stay as it is, be modified or be deleted. (Table 7.2) The feedback from their evaluation was then analysed and used for further refinement of the model. The original model sent to participants (before modification) for validity and test can be seen in Appendix D. The final modification was then carried out according to the feedback from the field test, as shown in Table 7.3.

Table 7.2: Useful feedback to improve the LSSMM

No.	Experience	Feedback	Action for improvement
1	− Lean Champion − 7 years' experience in Lean project deployment − Involved in more than 25 Lean projects in Saudi and Singapore	1. He made modifications to the levels of maturity (in the text) 2. If anything, me being a technical person, I would like to see more on the processes on the LSS execution side. So, how the LSS is done by the organisation, what tools and techniques are used? Are they doing an A3 problem statement only or also VSM, Fishbone, FMEA, etc.	1. The maturity levels were modified based on the comments and more explanation added, as suggested 2. The tools and techniques category was added to the model to measure the organisation's maturity in terms of the advancement of tools normally used in LSS

			projects.
2	− LSS BB and operational excellence manager − 6 years' experience in LSS project deployment − Involved in 9 LSS projects plus delivery of GB and YB training	The model looks sensible; I find it clear, user friendly and well structured. A couple of comments: 1. The language used and abbreviations (e.g. LSS) assume prior knowledge of the user. This is fine if it is assumed the user knows about LSS. 2. The model in some aspects seems tailored to larger companies. For instance, I haven't seen MBB, BB, GB, YB, WB structure in smaller companies in Saudi. Smaller companies can also struggle to have a full time LSS resource or deliver training internally.	1. Abbreviations such as LSS, MBB, BB, etc. were explained under the model. 2. This point was added to the future research plan, to test the model in SMEs.
3	− LSS BB, operation assessment and section head − 3 years' experience in LSS project deployment − Involved in 4 LSS projects plus delivery of GB and YB training	Overall I think it is a good model, but I have noticed that some points have two categories: e.g. in strategic alignment the first statement said (Strategic goals are not clear and not linked to LSS and there is no strategy for CI in place). I think you should pay attention to that.	Some activities were rewritten to be clearer for the users.
4	− LSS BB and customer service manager − 5 years' experience in LSS project deployment − Involved in 5 LSS projects plus delivery of GB and YB training	Actually the model is solid and it covers the main elements to assess the LSS maturity. I would like to add one point that could be helpful to improve the model, consider looking at the HR systems in the organizations e.g. is it mandatory to complete a certain level of LSS certification to have certain career progress.	This point was added to the opportunities for improvement in Table 7.5, i.e. more categories can be added such as LSS certification and its link to career progress.
5	− LSS MBB − 7 years' experience in LSS project deployment − Involved in more than 15 LSS projects, plus delivery of GB and YB training and providing assistance for BBs in LSS projects	I think the activities are pertinent and focused on gauging the LSS maturity level in Saudi organisations in specific, since LSS is still in nascent stages in most of the Six Sigma companies.	No action needed
6	− LSS consultant and professor in quality and CI − 11 years' experience in LSS and CI teaching and consultation in Saudi Arabia	The model is very solid and seems to be practical but I would add one more category to measure the LSS maturity in tools and techniques, as I see plenty of organisations in Saudi stuck to simple tools.	− The tools and techniques category was added to the model to measure the organisation's maturity in terms of the advancement of tools normally used in LSS projects.
7	− LSS MBB − 6 years' experience in LSS projects deployment in Saudi	In general, the model is very useful but I realised that tools and methods were ignored in the model although they are one of the main components of LSS projects.	− The tools and techniques category was added to the model to measure the organisation's maturity in

	private sector − Involved in more than 12 LSS projects plus delivery of BB training		terms of the advancement of tools normally used in LSS projects.
8	− Six Sigma BB − 6 years' experience in Six Sigma project deployment in Saudi public sector − Involved in around 10 Six Sigma projects	I think the model is acceptable, I suggest slight amendments in the levels. 1. I suggest to add in level 1 that top management and leadership know about LSS approach through literature review, news of successful stories, newsletters, etc. This creates a desire to explore this field (pre-feasibility study) and assess benefits and costs of advancing forward in this field. 2. Level 3 is O.K, but I am afraid that the word 'capability' would be confused with the term 'process capability', which is frequently used by Six Sigma practitioners. I suggest using another word that gives the same meaning or use 'deployment'.	1. This statement was added in the description of level 1, but it was not added to the model because the model should stay clear and simple. 2. The word capability was explained further to eliminate the confusion
9	− LSS MBB − 8 years' experience in LSS projects and coaching in financial sector − Involved in 8 LSS projects	The model is well-organised and highly acceptable. However, I have some suggestions in the categories: - I think it is better to add a new category: (tools and techniques) to guide organisations about the required tools in each level.	The tools and techniques category was added to the model to measure the organisation's maturity in terms of the advancement of tools normally used in LSS projects.
10	− LSS MBB − 7 years' experience in running LSS projects and Setting up Lean leadership programme	-The model is very good and clear and covers the aspects of culture, competency, leadership, strategic alignment, project selection and prioritisation, recognition, returns, and motivation to sustain	No action needed.
11	− LSS and CI consultant − 10 years' consultation experience in the Saudi market	I am not sure I agree with the 'White Belt' reference; I cannot think of a company I have visited in Saudi that uses this terminology. From what I have seen Yellow Belt (although varied in what this means between companies) tends to be the entry level training.	White Belt training was removed and 'awareness sessions' was used instead.
12	− LSS champion − 10 years' experience in LSS in Saudi and Egypt − Involved in more than 14 LSS projects	My comment on the ROI part, when companies enforce the LSS on employees with target dates to complete projects, for example, each employee has to complete one project annually. The ROI could be lower because the employee might try to close the project to achieve the deadline rather than properly completing the project.	-The author argues that ROI from LSS should be calculated in each year, because ROI can be used as a measure of the success of the programme.
13	− LSS BB and CEO for chemicals company − 2 years' experience in LSS − Involved in 3 LSS projects	The model seems good and realistic to measure LSS maturity in Saudi organisations; however, based on my experience as a CEO I believe that it is too early to measure innovation in level 4 but I can see innovation start in level 5 where employees can do the work in a more innovative way.	Based on this comment and according to the literature, innovation was moved to maturity level 5.
14	− Lean consultant	I have 3 minor comments on the model:	

− 5 years' experience in Lean projects and consultancy work	1. It is very important to look at the maturity of tools used in LSS projects 2. In the third category 'strategic alignment' in level three you stated '…and projects are suggested based on this alignment' but you already in the next category said 'Projects are selected based on a set of criteria using a project selection matrix …' I think it is confusing. 3. In the fifth category i.e. motivation I would say level 0 has no recognition at all while in level 1 there is recognition but not on a regular basis, in other words, only when the manager or the CEO decides to reward people who are involved in some projects.	1.The tools and techniques category was added to the model to measure the organisation's maturity in terms of the advancement of tools normally used in LSS projects. 2. The activity in category 3 level 3 was reworded to eliminate the confusion 3. The activity was modified as suggested

Pilot testing of the model helped the author to get additional feedback to refine the model and ensure its applicability to assess the current level of LSS maturity in the targeted organisations, i.e. Saudi organisations. However, some modifications were also made to the model, which were explained in the 'action for improvement' column in the table above.

The next section provides in-depth explanation and definitions for maturity levels, characteristics in each level and the main activities that the organisation needs to engage in, in order to move to the next level.

7.5 The proposed practical LSS maturity model (LSSMM)

It was essential and of value to develop a maturity model for LSS assessment to bridge the gap in the literature, taking into consideration the limitations of previous models. The proposed model shown in Figure 7.2 is thus a combined model consisting of five maturity levels and seven categories which were derived from but not limited to those covered the review of the available models presented in Chapter 2 (Bessant and Francis, 1999; Bessant et al., 2001; Choudhury, 2012; Cronemyr and Danielsson, 2013; Crosby, 1979; Fryer et al., 2013; Lee et al., 2011; Maier et al., 2012; Olson and Sinn, 2011; Röglinger et al., 2012; SEI, 2005; Shere, 2003; Valadão et al., 2013; Watson-Hemphill and Bradley, 2012; Zhen, 2009) and from unpublished maturity models used by world-class organisations. Interviews with the final users of the model, the most common CSFs for LSS in Saudi Arabian organisations, and finally, feedback from pilot testing were used for the final stages of refinement. Each level in the model has activities or constituent behaviours and characteristics, organised under the key categories.

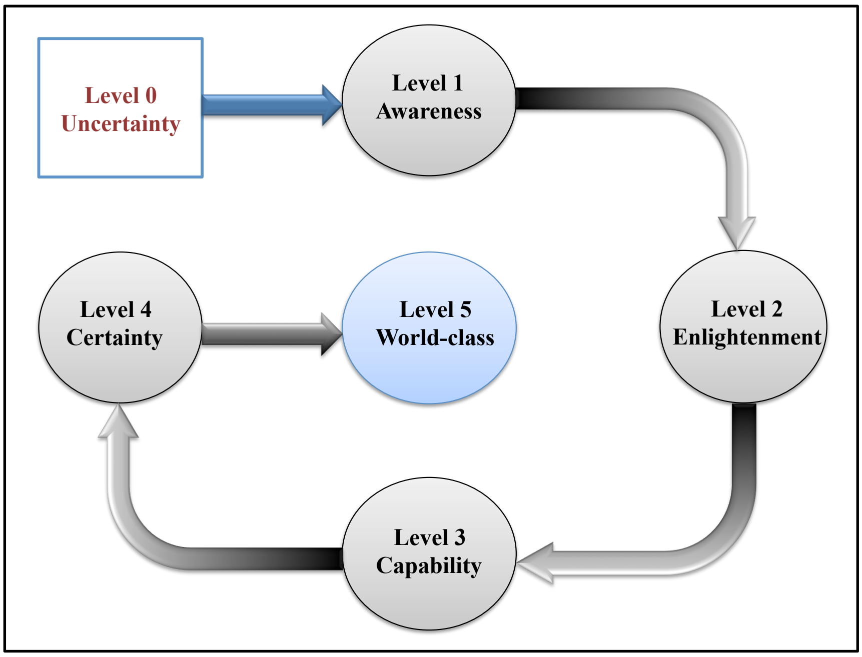


Figure 7.2: Lean Six Sigma Maturity levels

7.5.1 Maturity categories

The proposed LSS maturity model consists of seven categories, which are:

1- Infrastructure and training

This category focuses on the maturity of the LSS infrastructure and the level of LSS training provided for employees and managers in the organisation in each maturity level.

2- Top management commitment and leadership

This category measures the contribution of the top management and leadership to LSS implementation and success. Top management and leadership should have a major role in supporting LSS, e.g. in allocating resources for projects and training, planning investment, attending performance meetings and LSS events, removing barriers that face the LSS team and involvement in project selection.

3- Strategic alignment

Strategic alignment is one of the most important categories to measure LSS maturity. This category focuses on the formulation of the organisation’s strategic goals and their alignment with LSS projects. The strategic alignment helps the organisation to reach a high level of LSS maturity until LSS becomes ‘the way things are done’, integrally aligned with the execution of the corporate strategy, and also extends to customers, stakeholders, the supply chain, and all business functions.

4- Project selection and prioritisation

This category explains the activities related to project selection and prioritisation at each maturity level, the approach followed for this activity at each level, and the level of senior management and champions' involvement at each maturity level.

5- Tools and techniques

Tools and techniques that are regularly used in LSS projects can clearly indicate the maturity level of LSS in organisations. For instance, using simple tools from the Lean toolbox and avoiding other statistical tools and techniques from the Six Sigma toolbox can indicate that LSS is not mature enough. Therefore, this category helps the model user to measure the level of LSS maturity from the technical angle.

6- Motivation and recognition

Most of the reviewed maturity models for business process excellence (in Chapter 2) appear to ignore the motivation and recognition category, although it is one of the main components to ensure LSS maturity and sustainability. Hence, the presence of motivation and recognition factors in the proposed model will help organisations to measure their level of LSS maturity from the human resource aspect.

7- Financial benefits (ROI)

In the literature, financial benefits were cited as the main motivation for LSS deployment. However, this factor was not a priority for most of the Saudi organisations when deploying LSS initiatives. Hence, it was important to include this category in the proposed model, to help organisations to understand their level of maturity based on the financial benefits they gain from LSS.

7.5.2 Maturity levels

Each maturity level, from level 0 to level 5, is explained in detail in the forthcoming sub-sections.

7.5.2.1 Level 0: Uncertainty

This level has been formalised for organisations that are unsure about the adoption of Lean or Six Sigma. Organisations at this level might have some personnel previously trained for LSS by previous organisations that they worked for. There may be some degree of awareness in one department but no projects have been previously implemented using Lean or Six Sigma tools (Watson- Hemphill and Bradley, 2012). Therefore, this level is not considered to be a part of the maturity scale, since it is not a foundation for the other levels. At this level, the quality initiatives are limited to compliance with ISO standards and the use of basic quality tools such as cause and effect analysis, check sheets or control charts (Choudhury, 2012), whereas CI initiatives are rarely implemented or fail to be sustained. Therefore, this level has been termed 'Uncertainty', as a result of the managers' and employees' lack of knowledge concerning LSS and CI in general and their benefits to the business, as well as the lack of a long-term plan for CI (Dale and Lascelles, 1997). The main characteristics of this level are derived from many sources (e.g. Bessant et al., 2001; Choudhury, 2012; Dale and Lascelles, 1997; Li and Lin, 2011; Mader, 2007; Nightingale and Mize, 2002; Olson and Sinn, 2011; Zhen, 2009). These characteristics are:

- Lack of training for employees and managers, although there are some individuals trained for LSS by external specialists or consultants, and there is a clear lack of internal expertise to solve business problems, and lack of LSS infrastructure (Bessant et al., 2001; Shere, 2003; Watson-Hemphill and Bradley, 2012).
- Lack of top management commitment and involvement (Olson and Sinn, 2011).
- Strategic goals are not clear or not linked to LSS and there is no strategy for CI in place (Bessant et al., 2001; Dale and Lascelles, 1997).
- Project selection is by GBs or BBs and based on the most common problems (Watson-Hemphill and Bradley, 2012).
- Using basic quality tools to solve simple problems, such as cause and effect analysis, check sheets, control charts and histograms (Choudhury, 2012; Dale and Lascelles, 1997).
- No recognition system in place, with very low motivation for LSS across the organisation (Bessant et al., 2001).
- ROI is never measured or there is no financial return generated yet (Watson-Hemphill and Bradley, 2012).
- Lack of awareness across the organisation regarding the benefits of LSS (Watson-Hemphill and Bradley, 2012).
- Poor employee morale (Bessant et al., 2001).
- More focus on products rather than processes and relying heavily on final inspection (Dale and Lascelles, 1997).
- No strategy for CI in place (Dale and Lascelles, 1997; Watson-Hemphill and Bradley, 2012).

- Lack of investment in people, technology, research and development, infrastructure and cost-cutting (Dale and Lascelles, 1997).
- Poor levels of customer satisfaction (Dale and Lascelles, 1997).
- Lack of internal and external communication (Boughzala and de Vreede, 2012).
- High resistance to change and a blame culture is dominant (Watson-Hemphill and Bradley, 2012).
- Quality is the responsibility of certain individuals rather than everyone (Dale and Lascelles, 1997).
- Lack of organisational learning practices (Boughzala and de Vreede, 2012).
- Lack of process ownership (Xiaofen, 2013).
- Lack of employee engagement (Watson-Hemphill and Bradley, 2012).

Organisations located at this level do not exhibit any behaviour overtly supporting the success of LSS. Nonetheless, the behaviours in these organisations are impeding the implementation of LSS. However, to move organisations from this level to the next level, it is important to focus on:

- Formalising the strategic goals of the organisation and linking them to LSS (Mader, 2007).
- Arranging with a consultancy company to get started on the initiative e.g. providing training and consultancy (Bessant et al., 2001).
- Focusing on both process and products (Dale and Lascelles, 1997).
- Learning to use and implementing some simple tools, such as VSM, Cause and Effect Analysis, Pareto Analysis, Scatter plot. (Bessant et al., 2001; Dale and Lascelles, 1997; Watson-Hemphill and Bradley, 2012).
- Management commitment and involvement are needed to provide guidance in the implementation process of LSS (Shere, 2003).
- Create a clean and organised work area using the 5S tool (Choudhury, 2012)
- Recording quality data for the key processes and identifying the current process, so that LSS projects will be on time and within budget (Choudhury, 2012; Li and Lin, 2011; Shere, 2003; Zhen, 2009).

7.5.2.2 Level 1: Awareness

This level is officially the first level of LSS maturity, where organisations are trying out some basic LSS ideas but still in an ad hoc manner (Bessant et al., 2001; Boughzala and de Vreede, 2012; Cronemyr and Danielsson, 2013). Organisations at this level place more focus on quality but very little focus on CI methodologies. Top management and leadership know about the LSS approach through such sources as literature reviews, news of successful stories and newsletters.

At this level, organisations are in the early stages of implementation and in the process of building the foundation and infrastructure for LSS. Hence, this level has been named 'awareness', because organisations at this level are trying to disseminate LSS awareness into different organisational levels by focusing on training and on executing simple projects in one department rather than across the business, but mainly at the management level (Bessant et al., 2001; Cronemyr and Danielsson, 2013). As there is some awareness, there could be reactive deployment of LSS on an ad hoc basis, mostly with outside support, as project based initiatives. Typically, the benefits initially realised are not sustained. There is a risk that organisations get 'stuck' at this level, as, for their management, some short-term benefits can be obtained and typically aligned with job rotation and progression. The organisation has more focus on core and supporting processes rather than products (a reactive vs. proactive approach). They may be using DMAIC as the primary problem solving methodology (Jørgensen et al., 2007) and moving from gut feeling and intuition-based decisions to data-driven decisions (Bessant et al., 2001; Choudhury, 2012; Dale and Lascelles, 1997). At this level there is no relation between career progression and certification.

The main characteristics of this level are:

- The organisation has a formal LSS infrastructure in place to drive the initiative forward, supported by the senior management team, and LSS training is delivered for the most talented people, including YB, GB and BB (Shere, 2003). Initial investment in LSS has been planned to cover training from an external training provider, to increase the awareness of LSS (Shere, 2003).
- The management commitment and involvement is very critical for LSS success in the early stages, in providing guidance in the implementation process (Lee et al., 2011). Senior management allocate resources to relevant LSS belts in pursuing projects and plan investment in LSS. However, at this level there is still a lack of commitment from senior managers at performance meetings or project progress meetings (Dale and Lascelles, 1997; Shere, 2003).
- The strategic goals of the organisation are formalised and linked to LSS (Nightingale and Mize, 2002;Olson and Sinn, 2011).

- Projects are selected on an ad hoc basis based on their importance in the organisation – primarily projects are selected based on an Effort vs. Benefits model (Duarte et al., 2012; Zhen, 2009).
- There is an awareness of basic tools of LSS (e.g. VSM, Cause and Effect Analysis, Pareto Analysis, Scatter Plot) but the employees are not using them for problem-solving in an active manner (Bessant et al., 2001). There is more dominance of simple tools and techniques (Bessant et al., 2001) from the Lean toolbox that help to eliminate non-value-adding activities and improve the speed of business processes (Malmbrandt and Ahlstro, 2013).
- There is a small group of individuals in some departments who are motivated towards LSS projects, (Raje, 2009); however, they are not getting rewards on a regular basis.
- ROI of at least 1:1, starting from the early years of deployment (Pyzdek and Keller, 2014).

Nevertheless, organisations at this level still face some challenges in deploying LSS, such as the lack of a clear plan for LSS deployment throughout the organisation (Watson-Hemphill and Bradley, 2012). Moreover, organisational culture has not yet been changed by the implementation of LSS, and the high resistance to change is inhibiting the implementation of LSS (Watson- Hemphill and Bradley, 2012) and there are some individuals who still consider LSS as a temporary programme that will disappear over time. If LSS is not considered as a CI programme that will last forever (Watson-Hemphill and Bradley, 2012), there will be low alignment of LSS with the organisation's goals and objectives (Olson and Sinn, 2011). Some BBs may not be working full-time on LSS projects but working on LSS projects alongside their daily job. Project failures are also likely to occur, due to poor project selection (Olson and Sinn, (2011), and no formal reward and recognition system is in place. These challenges should be considered carefully in order to move to the next level. Additionally, organisations need to deliver LSS awareness sessions to employees on the shop floor (Shere, 2003).They need to use criteria for project selection, with some involvement of the LSS champion and create communication channels from the upper level to the bottom of the organisation (Coronado and Antony, 2002), as well as securing physical, financial and technical resources for LSS deployment (Watson-Hemphill and Bradley, 2012). More attention should be paid in this level to the critical roles of leadership, for example, of MBBs (Watson-Hemphill and Bradley, 2012).

7.5.2.3 Level 2: Enlightenment

Organisations at this level have a more structured and systematic LSS approach than in level 1. This level has been named ‘Enlightenment’, because organisations at this level have the ability to understand and learn more facts and new practices (Crosby, 1979) in regard to LSS deployment. Organisations at this level are actively implementing projects in more than one department and generating more soft benefits and financial savings, i.e. ROI of about 1:2 to 1:4 (Kubiak, 2012; Watson-Hemphill and Bradley, 2012). However, financial benefits are usually dominant (Kubiak, 2012). These organisations have moved past their own inertia in relation to LSS and have become self-learning. This level has more positive characteristics than level 1, including:

- Awareness of LSS at shop-floor level, through the awareness sessions, and more people are trained than in level 1 (Dale and Lascelles, 1997; Raje, 2009).
- Senior managers attend performance meetings and LSS events (OMG, 2008).
- Good problem definition, formulation and shared understanding among team members through effective teamwork (Bessant et al., 2001; OMG, 2008).
- Projects are selected based on a set of criteria, using a project selection matrix and there is some involvement of LSS champions in this exercise (Raje, 2009; Watson-Hemphill and Bradley, 2012; Zhen, 2009).
- Using more advanced problem-solving tools and techniques (Bessant et al., 2001) within DMAIC than the ones used in level 1 (e.g. Failure Mode and Effect Analysis, Poka Yoke, 5S, SMED) (Dale and Lascelles, 1997; Watson-Hemphill and Bradley, 2012).
- There is a formal reward and recognition system, but it is not well appreciated by the employees (Bessant et al., 2001; Shere, 2003).
- ROI is 1:2 to 1:4 (Kubiak, 2012; Watson-Hemphill and Bradley, 2012).
- Clear communication from senior management team to all levels about the importance of LSS (Dale and Lascelles, 1997; Raje, 2009; Zhen, 2009).
- Dedicated resources to provide training and allow time for employees to carry out projects (Watson-Hemphill and Bradley, 2012).

To move to the next level, organisations need to:

- Focus on hard benefits and financial benefits, to increase the bottom line (Raje, 2009).
- Ensure that LSS is deployed in all the business functions and makes positive impacts (Jørgensen et al., 2007).

- Create a reward and recognition system for employees who are involved in LSS projects (Watson-Hemphill and Bradley, 2012; Zhen, 2009).

7.5.2.4 Level 3: Capability

Organisations at this level have a strategic and planned LSS deployment. This level has been entitled ‘Capability’ because organisations that have reached this level are more proficient and capable to deploy LSS than those at levels 1 and 2. At this point the organisation becomes self-driven, as the benefits are evident and LSS has to start to change the organisation’s culture positively. The main characteristics of this level are:

- Development of a good LSS infrastructure, including YBs, GBs, BBs and possibly a MBB (if the number of employees is 1000 or more) (Raje, 2009; Snee, 2010).
- Top management assists the LSS team to remove barriers to LSS success (Dale and Lascelles, 1997; Raje, 2009).
- Each department’s goals across the organisation have been aligned with LSS (Dale and Lascelles, 1997; Jørgensen et al., 2007; Watson-Hemphill and Bradley, 2012).
- Projects are selected based on a set of criteria using a project selection matrix and there is an active involvement of LSS champions in this exercise (Choudhury, 2012).
- The majority of Lean tools must have been used in this stage of maturity and the more basic tools of Six Sigma, along with introduction of some basic statistical tools (Jørgensen et al., 2007; Raje, 2009; Watson-Hemphill and Bradley, 2012).
- There is a formal reward and recognition system which is well appreciated by the employees (Jørgensen et al., 2007).
- ROI is approximately 1:5 (Watson-Hemphill and Bradley, 2012).
- An effective and efficient performance measurement and management system is in place (Raje, 2009).

To move to the next level, the organisation needs to:

- Support organisational learning practices to distribute learning across the organisation (OMG, 2008).
- Collect more details about competitors and be fully informed about their products/services, pricing, quality level, and any improvements they have made, as part of learning from competitors (Dale et al., 2007; Dale and Lascelles, 1997; OMG, 2008).

- Understand that failure is a source for learning and success does not come without failure or negative experiences (Dale and Lascelles, 1997).

7.5.2.5 Level 4: Certainty

At this level, all the organisation members can deploy LSS projects, and advanced LSS tools and techniques are widely used in LSS projects. This level has been named 'Certainty', because LSS deployment becomes a belief and a dominant way of life and not only a method for improvement. In return, this leads to high employee morale and ownership, quick speed of project implementation (maximum of six months for BB projects) (Snee, 2010), as well as systematic use of suggestion schemes and idea generation. The most important characteristics at this level are basic organisational learning practices and supportive leadership; some shifts in organisational culture are also observed in this level. The main characteristics of this level are:

- Very solid infrastructure and in-house training through MBB and BB and DFSS training being in place (Fornari and Maszle, 2004; Voehl et al., 2013; Watson-Hemphill and Bradley, 2012).
- Top management are involved in project selection, reviewing project benefits and supporting organisational learning behaviours (Malmbrandt and Ahlstro, 2013).
- Some organisational learning practices are available and linked to LSS projects, e.g. sharing knowledge and learning from negative and positive experience (Zhen, 2009).
- There is a well-defined and documented project selection methodology, following a top-down approach and based on business strategy, with strong involvement of champions (Zhen, 2009).
- Employees and managers are intrinsically motivated towards the development of LSS initiatives (Zhen, 2009).
- ROI is approximately 1:8 (Snee, 2010).
- The organisation exhibits some aspects of the learning organisation, e.g. sharing knowledge and information, learning from negative and positive experience, learning from competitors. (Zhen, 2009).
- Leaders encourage team learning behaviours (Choudhury, 2012).
- HR and IT departments have a major role in supporting LSS deployment: for example, HR plans the training, reward, and recruitment, while IT provides software

for LSS projects when needed (Antony and Banuelas, 2002; Jørgensen et al., 2007; Salah et al., 2010; Sehwail and DeYong, 2003).

- Benchmarking against other organisations and visiting other organisations (competitors) to see how they adopted LSS in their work, culture, and business requirements, as they are a good source for learning and improvement (Dale et al., 2007; Dale and Lascelles, 1997; George, 2003; OMG, 2008).
- Using resources to the fullest (Dale and Lascelles, 1997; George, 2003; Srinivasan and Murthy, 2010).
- Selecting projects that bring higher financial benefits, while VOC and voice of the business are fully utilised in project selection (Zhen, 2009).

OL practices in this level can help LSS sustainability and survival; thus, in order to move to the next level and sustain LSS, as in world-class organisations, organisations in this level should:

- Carry out the work in a more innovative way and try new ideas of doing the work (Malmbrandt and Ahlstro, 2013).
- Have all the learning organisation aspects in place. This includes sharing thoughts and knowledge freely, and learning from both negative and positive experience (Bessant et al., 2001; Jørgensen et al., 2007).
- Ensure OL practices are part of the new culture that supports LSS (Bessant et al., 2001; Fryer et al., 2013; Jørgensen et al., 2007).
- Accept LSS as the dominant way of life and linked to other business functions (Jørgensen et al., 2007).
- Ensure everyone knows exactly the purpose of deploying LSS (Coronado and Antony, 2002).
- Develop a sustainability model for sustaining the results (Jørgensen et al., 2007).

7.5.2.6 Level 5: World-class

World-class level is for organisations that are progressing to the same level as leading organisations in LSS, such as GE, Xerox and Bank of America (Laureani and Antony, 2012; Snee, 2010; Timans et al., 2012), have the same characteristics as these organisations, and learn from them. In GE, the CEO Jack Welch successfully changed the organisational culture and employees' attitude towards Six Sigma as a way of working. He was involved in weekly and monthly project reviews and regularly visited sites to ensure that Six Sigma had been successfully integrated into the culture (Coronado and Antony, 2002). This helped the LSS approach to be sustained and become a ‘way of life’, not just a fixing method. Employees take the LSS concept outside the company environment and adopt it in their daily behaviours. In order to reach this level, organisations need more than 15 years of continuous improvement, which requires changing the organisational culture and drives LSS ‘into the DNA’ of the organisation (Raje, 2009). As a result, the characteristics of organisations at this level include the following features: doing things right the first time; organisations never have a shortfall in resources; there is no chance of missing data; customer satisfaction is very high; management change does not affect the progress of LSS; employees have the ability and motivation for self-skills development, and there is high employee engagement and active involvement throughout the LSS deployment (Coronado and Antony, 2002; Raje, 2009; Watson- Hemphill and Bradley, 2012). It also involves doing new things and applying innovative solutions to common problems (Li and Lin, 2011; Lin et al., 2009; Malmbrandt and Ahlstro, 2013; OMG, 2008). The main characteristics of this level were adopted from organisations that have reached a very advanced level in LSS, as reported in the literature. These characteristics are:

- Design for Six Sigma (DFSS) training is in place and BBs are capable of executing DFSS projects when needed, e.g. to design or launch new products or services (Watson-Hemphill and Bradley, 2012).
- All departments have a project champion for LSS, reporting to the deployment champion in the organisations, with strong commitment from top management (Chakravorty, 2009; Jaideep et al., 2004).
- LSS is culturally the way things are done, integrally aligned with the execution of the corporate strategy, and extends to customers, stakeholders, the supply chain, and all business functions; organisational learning is extensively and widely distributed across the organisation, plus learning from competitors, and benchmarking against other organisations, locally and globally (Fornari and Maszle, 2004; Watson-Hemphill and Bradley, 2012; Zhen, 2009).
- Projects are selected in a team environment, with very strong involvement of champions and VOC is fully utilised in project selection (Zhen, 2009).
- Use of very advanced tools and techniques has become a normal task (Choudhury, 2012; Watson-Hemphill and Bradley, 2012).
- There is a systematic rewards and recognition programme for LSS teams and belts,

created by the HR and Finance departments (Snee, 2010).

- ROI of up to 1:9 in large corporations (Breyfogle, 2003; Breyfogle et al., 2000).
- The organisation has a plan for LSS sustainability (Fornari and Maszle, 2004).
- The culture is favourable to LSS and LSS has improved the culture (Watson-Hemphill and Bradley, 2012).
- High level of communication between departments, employees from different departments, employees and leaders and other groups (Fornari and Maszle, 2004)
- Working in partnership with stakeholders (Dale and Lascelles, 1997)
- Top management is very committed and supportive towards LSS (Fornari and Maszle, 2004).
- Leaders are very supportive and visionary (Snee, 2010).

This section presents the final model produced from this study, which is one of the main contributions of this research. As shown earlier in this chapter, the model went through many processes and was subjected to validity testing (presented in section 7.8) in order to come up with the final version shown in Figure 7.2 and Table 7.3. The model has five levels of maturity, plus level 0, which is the pre-Lean Six Sigma maturity level.

Table 7.3: LSSMM

Organisations need to select one activity in each category which is the most applicable to them:

Categories	Maturity Level	Activities or Constituent Behaviours and Characteristics	Score
Infrastructure and training	0	Lack of training for employees and managers but there are some individuals trained for LSS by external specialists or consultants and there is a clear lack of internal expertise to solve business problems.	
	1	There is a formal LSS infrastructure in place to drive the initiative forward and LSS training is delivered for the most talented people, including YB, GB and BB.	
	2	Awareness of LSS at shop-floor level, through the awareness sessions, and more people are trained than in level 1.	
	3	All the above + development of a good LSS infrastructure, including YBs, GBs, BBs and possibly a MBB (if the number of employees is 1000 or more).	
	4	All the above + in-house training through MBBs and BBs and Design for Six Sigma (DFSS) training in place.	
	5	All the above + DFSS training is in place and BBs are capable of executing DFSS projects.	
Top management commitment	0	Lack of top management commitment and involvement.	
	1	Senior management allocate resources to relevant LSS belts in pursuing projects and plan investment in LSS.	

and leadership	2	Senior managers attend performance meetings and LSS events.	
	3	All the above + top management assist LSS team to remove barriers to LSS success.	
	4	All the above + top management involved in project selection, reviewing project benefits, and supporting organisational learning behaviours.	
	5	All the above + all departments have a project champion for LSS, reporting to the deployment champion in the organisation, with strong commitment from top management and support for innovation.	
Strategic alignment	0	Strategic goals are not clear or not linked to LSS and there is no strategy for CI in place.	
	1	The strategic goals of the organisation are formalised and linked to LSS.	
	2	Good problem definition, formulation and shared understanding among team members through effective teamwork.	
	3	All the above + each department's goals across the organisation have been aligned with LSS.	
	4	All the above + some organisational learning practices are available and linked to LSS projects, e.g. sharing knowledge, learning from negative and positive experience.	
	5	All the above + LSS is culturally the way things are done, integrally aligned with the execution of the corporate strategy, and extends to customers, stakeholders, supply chain, and all business functions; organisational learning is extensively and widely distributed across the organisation, plus learning from competitors, and benchmarking against other organisations, locally and globally.	
Project selection and prioritisation	0	Project selection is by GBs or BBs and based on the most common problems.	
	1	Projects are selected on an ad hoc basis, based on their importance in the organisation – primarily, projects are selected based on Effort vs. Benefits model.	
	2	Projects are selected based on a set of criteria using a project selection matrix and there is some involvement of LSS champions in this exercise.	
	3	Projects are selected based on a set of criteria using a project selection matrix and there is an active involvement of LSS champions in this exercise.	
	4	There is a well-defined and documented project selection methodology, following a top-down approach and based on business strategy, with strong involvement of project champions and leaders, such as BBs.	
	5	Projects are selected in a team environment, with very strong involvement of champions and VOC is fully utilised in project selection.	
Tools and techniques	0	Using basic quality tools to solve simple problems, such as cause and effect analysis, check sheet, control chart and histogram.	
	1	There is an awareness of basic tools of LSS (e.g. VSM, Cause and Effect Analysis, Pareto Analysis, Scatter plot) but the employees are not using them for problem solving in an active manner.	
	2	Using more advanced problem-solving tools and techniques within DMAIC than the ones used in level 1 (e.g. Failure Mode and Effect Analysis, Poka Yoke, 5S, SMED).	
	3	Majority of Lean tools must have been used in this stage of maturity and the more basic tools of Six Sigma, along with introduction of some basic statistical tools.	
	4	Lean tools and Six Sigma statistical tools and techniques are widely used in LSS projects.	

	5	Use of very advanced tools and techniques has become a normal task.	
Motivation and recognition	0	No recognition system in place, with very low motivation for LSS across the organisation.	
	1	There is a small group of individuals in some departments who are motivated for LSS projects, although they are not getting rewards on a regular basis.	
	2	There is a formal reward and recognition system, but not well appreciated by the employees.	
	3	There is a formal reward and recognition system, which is well appreciated by the employees.	
	4	Employees and managers are intrinsically motivated towards the development of LSS initiatives.	
	5	Systematic rewards and recognition programme for LSS team and belts created by HR and finance departments.	
Financial benefits (ROI)	0	ROI is never measured or there is no financial return generated yet.	
	1	ROI is at least 1:1, starting from the first year of deployment.	
	2	ROI is 1:2 to 1:4.	
	3	ROI is approximately 1:5.	
	4	ROI is approximately 1:8.	
	5	ROI is more than 1:9.	
Total Score			

Note for model user: LSS= Lean Six Sigma, MBB= Master Black Belt, BB= Black Belt, GB= Green Belt, YB= Yellow Belt.

The model developed in this study has some differences from the models that exist in the literature. Although the model was built on these previous models, it needed to be modified slightly in terms of elements concerning leadership, training, financial benefits and infrastructure. The main differences are:

1- Some further categories, activities or constituent behaviours and characteristics in the maturity model emerged from the interviews (as summarised in Table 7.1) and the model pilot-tested in Saudi Arabia (Table 7.2), for example, the tools and techniques categories.
2- The model considered the missing categories and activities in some of the other models, for example, leadership, innovation, organisational learning, human factors, motivation and recognition and return on investment.
3- The model has a system of scoring criteria, which was missing in most of the previous models. This system helps the user to determine and understand more or less where they are and where they want to go in terms of LSS maturity.
4- This model aims to be clearer and more user friendly (based on the feedback from participants) and to provide more accurate results for the targeted sector than the previous models reviewed in Chapter 2, such as CMMI. For instance, one of the LSS

experts involved in testing the model stated that 'The model looks sensible; I find it clear, user-friendly and well-structured'.

7.6 Scoring criteria

The systematic review for the available maturity models highlighted that one of the limitations of previous maturity models for quality, continuous improvement and business process improvement was the lack of scoring criteria e.g. in Lin et al. (2009), Li and Lin (2011) Malmbrandt and Ahlstro (2013) and Watson- Hemphill and Bradley, (2012). Scoring criteria were found to be critical for the model's effectiveness, and thus it is essential to measure the current level of implementation. Therefore, the aim of this section is to develop a set of scoring criteria for the established model (LSSMM). These criteria help users to determine the current level of maturity, and to decide when the level is achieved and how to move to the next level.

The criteria used in this model were adopted from the "rubric scoring system" used in maturity models for different purposes, such as managing change (Andrade, 2011), or quality (Wilson, 2015). This system allows the model user to select the most applicable activity (only one activity) in each category and this will directly indicate the level of maturity in each category. If the user selects level 4, for example, in each category, that means the activity/characteristic in that category in previous levels (1, 2 and 3) has been carried out or achieved in the past. By selecting the description that best matches the organisation, users build up a more sophisticated and complete view of their LSS maturity level. This scale can give two outputs generated by the model:

1- Overall maturity score
2- Categories maturity scores

The scoring criteria are based on a 0-5 scale, where 0 is very low (uncertainty level) and 5 is very high (world-class level). In each category there are six levels of maturity, from 0 to 5. The model users need to select one activity/characteristic in each category which is the most applicable to them. The score for each activity/characteristic will be the number presented in front of that activity/characteristic in the level column. After selecting one activity/characteristic in each category, the score for each of the seven categories is summed up to obtain the total score.

Table 7.4: Score level for the LSSMM

Score	Maturity level
29-35	Maturity Level is 5 (World-class)
22-28	Maturity Level is 4 (Certainty)
15-21	Maturity Level is 3 (Capability)
8-14	Maturity Level is 2 (Enlightenment)
1-7	Maturity Level is 1 (Awareness)
<7	Maturity Level is 0 (Uncertainty)

As shown in table 7.4, the highest score is 35, which can be achieved by reaching level 5 in each maturity category, which is world-class level. On the other hand, organisations that have less than seven points (overall) cannot be described as LSS organisations, because LSS in these organisations is at level 0 or uncertainty level. These organisations and other organisations which have less than 30 points need to use this model to guide organisations for future improvement: in this, the user needs to address all the activities/characteristics that are not yet implemented in their organisations, to allow them to achieve higher maturity levels.
According to the scoring system, organisations can be located between 2 or 3 maturity levels, depending on the number of activities that are applicable to the organisation. For example, some organisations might be engaged in some LSS activities from level 1 plus other activities from level 2 and a few activities from level 3. In this situation the model helps the organisation to find out what activities are missing in order to move to higher levels than their present level. The organisations that achieve more than 28 points (the total score of the first 4 levels) have reached the world-class level, according to the model. More activities then need to be improved in order to achieve the full score, which is 35.

7.7 SWOT analysis on Lean Six Sigma maturity model

SWOT analysis is a study undertaken to identify the internal strengths and weaknesses of an organisation, as well as the external opportunities and threats (Antony, 2012), and is used in operations management and in Six Sigma (Antony, 2012). This analysis also is an effective technique to analyse and evaluate the strengths, weaknesses, opportunities, and threats of this model. This step was very critical in order to increase the validity and the effectiveness of the model, as shown in Table 7.5. It also gives a direction for further improvement of the model in future work. It was observed that developers of previous models never used this technique or any other techniques for model evaluation. Therefore, using SWOT analysis for the validity of LSSMM is a positive aspect and one of the strengths of this model. The SWOT analysis was conducted by the researcher and reviewed by four people (two academics and two LSS practitioners) for more validity and credibility.

Table 7.5: SWOT analysis for LSSMM

	Helpful	Harmful
Internal Origin	**Strengths:** - User friendly, understandable and easy to use - No need for training or experience - Based on theoretical background, popular previous models (CMM, CMMI, Bessant, Crosby, Lean and Six Sigma models), practitioners' models in MMs (unpublished) from companies who have used LSS for over 20 years and empirical study - Considers the human aspects (HR role, employees' morale and ownership, leadership) and the role of IT to support LSS - Measures the maturity of LSS implementation activities - Performance-based scoring system (scoring criteria) - Clearly determines the current level based on the seven categories - Provides more accurate results for the targeted sector - Very flexible in measuring the current level of LSS and guiding the organisation to plan future activities to improve the level of LSS implementation - Tested and validated in five organisations in Saudi Arabia - Addresses the weaknesses of previous models - Applicable for any organisation, even if not utilising LSS, as long as they are using CI tools and methodologies	**Weaknesses:** - Not generalised - Most likely to be used by people who have all the information about LSS in the organisation e.g. champions and MBBs - Each of the maturity activities/ characteristics and categories were given equal importance when calculating LSS maturity scores
External Origin	**Opportunities:** - Could be more advanced and generalised if was tested in more organisations - Can be applied for organisations in other Middle Eastern countries, if they have similar characteristics to Saudi Arabian organisations - More categories can be added, such as LSS certification and its link to career progress	**Threats:** - Many other models already exist - Resistance to change in some organisations might lead to lack of interest in using the model to improve the LSS deployment level

7.8 Validity and testing of the maturity model

To increase the validity and the accuracy of the model it was tested and modified through 14 academics, practitioners and experts in Lean and Six Sigma in Saudi Arabia, as explained in section 7.4. Subsequently, the model was used to assess the level of LSS maturity in the five organisations used in the case studies in Chapters 5 and 6. The aim of this assessment is to test the validity of the model, as suggested by a number of authors in the field of building and developing maturity models, including García-Mireles et al. (2012) and Wendler (2012). To be described as an efficient model for organisations, a model should be valid, reliable and cost efficient (Röglinger et al., 2012).

7.9 Assessment of Saudi Arabian organisations using the LSSMM

The final stage in developing the LSS maturity model was to identify the current level of LSS maturity in the organisations that participated in the third phase of the research i.e. the case study organisations. The purpose of the assessment was to get a final indication of the current status of LSS in the participating Saudi organisations, which was the first objective of this research (as presented in Chapter 1) and to give recommendations for further improvement in these organisations. The second purpose of this assessment was to increase the validity of the developed maturity model. The final model (shown in Table 7.3) was sent to the champion or the MBB in each case organisation and they were asked to use the model to evaluate the current status of LSS in their organisations which is the fifth phase of the research (refer to figure 3.2). The results are presented in Table 7.6.

Table 7.6: The current level of LSS in the case organisations

Maturity Categories	A	B	C	D	E
1- Infrastructure and training	4	1	1	0	1
2- Top management commitment and Leadership	4	3	2	2	2
3- Strategic alignment	4	2	1	3	2
4- Project selection and prioritisation	3	2	0	1	0
5- Tools and techniques	3	2	2	2	1
6- Motivation and recognition	2	1	1	4	1
7- Financial benefits (ROI)	2	0	0	1	1
Total Score	22	11	7	13	8
Current level	Level 4 Certainty	Level 2 Enlightenment	Level 1 Awareness	Level 2 Enlightenment	Level 2 Enlightenment

The main aim of this research was to assess empirically the current level of LSS within Saudi Arabian organisations and to develop a maturity model for those organisations to help them assess their LSS maturity level. This section of the research has contributed to achieving the research aims by assessing the current level of LSS in the five Saudi organisations which participated in the third phase of the research, as illustrated in Figure 7.3.

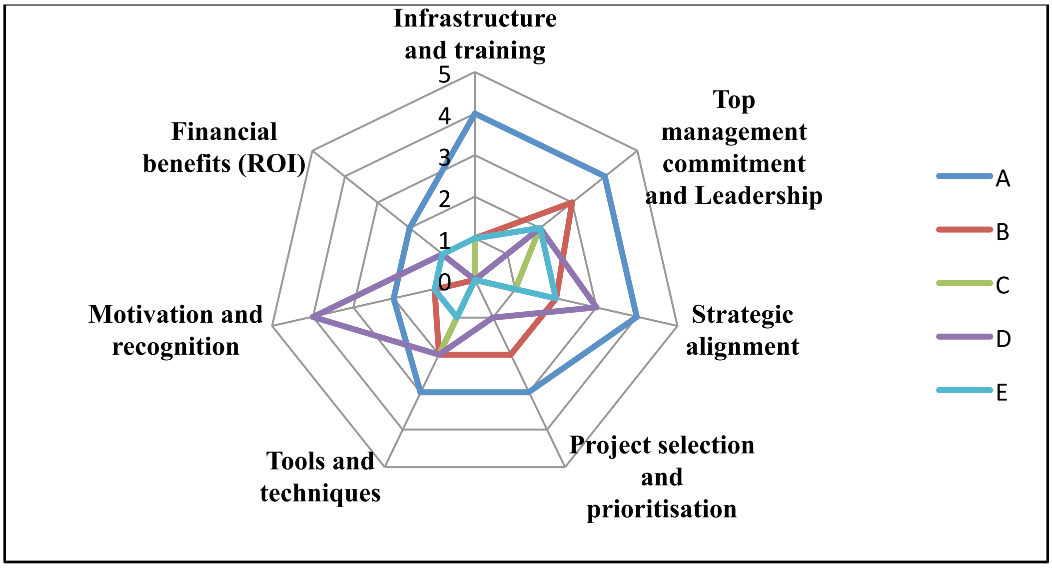


Figure 7.3: LSS Maturity level in the case organisations, based on the maturity categories

Organisation A

The total score of 22 out of 35 for LSS maturity in organisation A indicated that LSS deployment was at level 4, which is the Certainty level. This organisation achieved the highest maturity level in the five case organisations. This was due the strong infrastructure and training and strong commitment from top management, as well as strong strategic alignment of LSS to the organisation's goals. However, to improve, the organisation would need to pay more attention to the last two categories, which are motivation and recognition and ROI. For example, organisation A had a reward system, but it was not well appreciated by employees. In the interview phase, the employees stated that, although there was a reward system for the LSS team, they rarely received rewards, and other interviewees, e.g. BBs, stated that they were never rewarded for LSS projects. This was due to lack of financial benefits in some projects, as not all projects can generate financial saving. Therefore, the organisation needs to focus more on ROI and the financial benefits achieved from LSS projects. As mentioned earlier, in Chapters 5 and 6, financial benefits were not a priority for most of the case organisations. However, in order to achieve a higher maturity level, it would be important to generate more financial benefits, which in turn would allow the organisation to reward their employees for successful projects. The following recommendations are aimed to help organisation A to move to level 5, the highest maturity level:

1- Design for Six Sigma (DFSS) training should be in place and BBs should be capable of executing DFSS projects.
2- All departments should have a project champion for LSS, reporting to the deployment champion in the organisation, with strong commitment from top management and support for innovation.
3- LSS should be culturally the way things are done, integrally aligned with the execution of the corporate strategy, and extending to customers, stakeholders, supply chain, and all business functions; organisational learning should be extensively and widely dispersed across the organisation, plus learning from competitors, and benchmarking against other organisations, locally and globally.
4- There should be a well-defined and documented project selection methodology following a top-down approach and based on business strategy, with strong involvement of project champions and leaders, such as BBs.
5- There should be wide use of Lean tools and Six Sigma statistical tools and techniques in LSS projects.
6- A formal reward and recognition system should be created that is well appreciated by the employees.
7- ROI should be no less than 1:5.

Organisation B

The maturity level of LSS for organisation B was found to be at level 2 (Enlightenment), with a total score of 11 out of 35. This was due to the weak LSS infrastructure: e.g. at the time of the interviews, the organisation had no YB. no GB and no MBB, while there was only 1 BB and one deployment champion. Although the organisation had been deploying Lean since 2012, Six Sigma deployment was still in the early stages, with lack of motivation and recognition, and the ROI from LSS projects had never been calculated. Moving to the next level of maturity – level 3 – would require major improvements to be implemented, as follows:

1- Carry out LSS awareness sessions at shop-floor level and train more people than at present.
2- Top management has to become involved in project selection, reviewing project benefits and supporting organisational learning behaviours.
3- Each department's goals across the organisation have to be aligned with LSS.

4- Projects need to be selected based on a set of criteria, using a project selection matrix, and with active involvement of LSS project champions in this exercise.
5- The majority of Lean tools should be used and the more basic tools of Six Sigma, along with introduction of some basic statistical tools.
6- A formal reward and recognition system should be created.
7- ROI should be at least 1:1.

Organisation C

The total score of 7 out of 35 for LSS maturity in organisation C indicated that LSS deployment was still at level 1, which is the Awareness level. This organisation had very weak infrastructure and very few people trained for LSS. In addition, the commitment and involvement of top management and leadership was very poor. The strategic alignment also needed to be improved and the use of more advanced tools and techniques in future projects is strongly recommended. The organisation needed major improvement in project selection and prioritising, employee motivation and recognition and planning the financial benefits, as shown in Figure 7.3. In order to move to the next level, organisation C would be recommended to:

1- Carry out LSS awareness sessions at shop-floor level and train more people.
2- Ensure more assistance from top management for the LSS team, to remove barriers to LSS success.
3- Ensure good problem definition, formulation and shared understanding among team members through effective teamwork.
4- Start to select projects on an ad hoc basis, based on their importance in the organisation – primarily projects can be selected based on the Effort vs. Benefits model.
5- Make use of the majority of Lean tools and more basic tools of Six Sigma, along with introduction of some basic statistical tools.
6- Create a formal reward and recognition system.
7- Aim for ROI of at least 1:1.

Organisation D

The total score for LSS maturity in organisation D was 13 out of 35, which put the LSS maturity at level 2, Enlightenment level. Although this organisation was a multinational with a parent organisation in France, the LSS level of maturity was found to be very poor. The lowest score in the categories was for infrastructure and training, which was 0. This was followed by scores of 1 for top management commitment and leadership, project selection and prioritisation and ROI. The highest score was 4, for the strategic alignment and motivation and recognition categories. In order to move to the next level, organisation D needs:

1- A formal LSS infrastructure in place to drive the initiative forward and to deliver LSS training for the most talented people, including YB, GB and BB.
2- More assistance from top management for the LSS team to remove barriers to LSS success.
3- Some organisational learning practices to be applied and linked to LSS projects, for example, sharing knowledge and learning from negative and positive experience.
4- Selection of projects based on a set of criteria, using a project selection matrix, with some involvement of LSS project champions in this exercise.
5- To make use of the majority of lean tools and more basic tools of Six Sigma, along with introduction of some basic statistical tools.
6- A systematic reward and recognition programme for the LSS team and belts, created by the HR and Finance departments.
7- ROI of between 1:2 and 1:4.

Organisation E

The total score for LSS maturity in organisation E was 8 out of 35, indicateding that the LSS maturity was at level 2, the Enlightenment level. The weaknesses of LSS in organisation E were due to lack of project selection and prioritising criteria, lack of LSS infrastructure and training, using very simple and basic tools and techniques, lack of motivation and recognition and lack of financial benefits from LSS projects. Hence, in order to move to the next level of maturity and improve the level of deployment, organisation E would need to consider the following recommendations:

1- Carry out LSS awareness sessions at shop-floor level and train more people than at present.
2- More assistance from top management for the LSS team to remove barriers to LSS success.
3- Make sure each department’s goals across the organisation are aligned with LSS.
4- Select projects based on a set of criteria using a project selection matrix, with some

involvement of LSS project champions in this exercise.

5- Use more advanced problem-solving tools and techniques within DMAIC than the ones used in level 1 (e.g. Failure Mode and Effect Analysis, Poka Yoke, 5S, SMED).
6- Create a formal reward and recognition system.
7- Aim for ROI of between 1:2 and 1:4.

Unfortunately, none of the case organisations was found to have reached the world-class level, even the multinational organisations and those local organisations which were in joint ventures with other organisations in Western countries. Thus, it is important for the organisations to take the steps suggested above in order to improve their level of LSS deployment and obtain more benefits from the initiative.

For instance, organisation A could aim to move to level 5, which is the World-class level, where the LSS is sustained and becomes a 'way of life', rather than just a fixing method. The recommendations given to Organisations B, D and E were aimed to help them to move to level 3, which is the Capability level, where the organisation becomes more proficient and capable to deploy LSS than organisations at lower levels. Finally, organisation C could move to level 2, which is Enlightenment level, with a more structured and systematic LSS approach and the ability to understand and learn more facts and new practices in regard to LSS deployment.

7.10 Chapter summary

This chapter has contributed to the LSS field in developing a maturity model for Lean Six Sigma. The development of this model was an attempt to bridge the research gap, which is the absence of a Lean Six Sigma maturity model, without which organisations deploying LSS cannot assess their current maturity level. The model was developed for Saudi Arabian organisations after an in-depth analysis of the available maturity models. The Lean Six Sigma Maturity Model (LSSMM) comprises a number of levels of maturity, characteristics and scores. The model then was tested and validated through interviews with experts in the field and it was then used to assess the current level of LSS maturity in five Saudi Arabian organisations. This model has the potential to make a significant contribution to knowledge and practice, although it also has some limitations, which will be presented in detail in the final chapter, together with suggestions for further future development.

CHAPTER EIGHT
Discussion of Key Findings

8.1 Introduction

This study was conducted to assess the current level of Lean Six Sigma adoption within Saudi Arabian organisations and thereby develop a maturity model to assess the level of LSS implementation in Saudi organisations. The research gaps and research objectives were identified and presented in Chapter 1 and an empirical study was conducted to achieve the research objectives (see Chapters 4, 5, 6 and 7). This chapter discusses the key findings of the empirical research and maps the results against the literature.

8.2 Discussion of the key findings from empirical research

This section discusses the key findings, in terms of the size of the organisations and the use of ISO and TQM as a foundation of the LSS approach and compares the time of introduction in private and public organisations. This is followed by an investigation of the current status of LSS in terms of awareness of LSS, training and infrastructure, issues related to BBs and champions, LSS tools/techniques and common benefits. Finally, the findings regarding the motivating factors for LSS deployment, the basic learning practices adopted and the use of maturity models in Saudi organisations are discussed.

8.2.1 There is a lack of correlation between size and LSS deployment

The organisations included in this study were different in aspects of size, such as number of employees, turnover, sector and type of business; however, these differences were found to have no impact on the LSS deployment level. This finding is aligned with the view of Kumar et al. (2009b), who argue that CI initiatives could be successfully implemented and generate benefits in any organisation, regardless of the sector or the organisation's size. Feng and Manuel (2008) found no correlation between an organisation's size and the length of time using Six Sigma. However, it has been suggested that the size of the organisation can determine the pattern of BBs to work either full-time or part-time. For instance, part-time BBs are more suitable for small organisations and also such organisations can rely on GBs instead of BBs (Nonthaleerak and Hendry, 2008). In this study it was found that BBs rarely worked full-time in LSS projects, even in large organisations. This is because the BBs were involved in LSS projects alongside their normal daily work. However, lack of full-time BBs leads to fewer projects being executed and fewer benefits, particularly financial benefits, as each full-time BB is required to generate financial return (Schroeder et al., 2008).

8.2.2 Use of ISO and TQM as a foundation for the LSS approach

The results show that 85% of the organisations participating in the survey and all the case study organisations used ISO as a foundation either for TQM or Lean Six Sigma. This clearly shows the high positive impact of ISO on the successful implementation of Lean and Six Sigma, as suggested by many authors, including Breyfogle (2003) who argues that there are clear benefits to the integration of ISO standards with LSS. In addition, Does et al. (2015) state that standards such as the ISO series afford guidelines for organising process control.

TQM was also used as a foundation for Lean and Six Sigma in two thirds of the survey organisations and in four out of the five case study organisations. It was observed that ISO was a foundation for LSS, whereas TQM was replaced by Six Sigma in all the case study organisations that had deployed TQM in the past. According to studies by Yang (2004) and Pyzdek and Keller (2014), TQM has failed to obtain the radical results that organisations have achieved by Six Sigma deployment. Therefore, many organisations have replaced TQM with Six Sigma to obtain more benefits, such as increased productivity, reduction in defects, reduced variation, increased financial benefits and change in the culture (Andersson et al., 2006; Yang, 2004).

In the present study it was found that ISO was the responsibility of the quality department in the case organisations, while LSS was not the responsibility of the quality department in organisations A and B. Organisation B had a team called the CI team and organisation A had the Six Sigma team, where both worked in isolation from the quality department. On the other hand, in organisations C and E, ISO and LSS were found to be the responsibility of the quality department.

The study revealed that in both organisations (C and E) the quality department had been restructured and centralised to be able to take the responsibility of both CI and ISO. According to the literature, quality is the responsibility of everyone and it is not necessary for organisations to have a centralised quality department in order to adopt LSS (Antony, 2013). From the 1980s, American organisations started to eliminate large quality departments and believed that employees should routinely use the tools and methods of root cause identification and elimination (Dale et al., 2007; Folaron and Chase, 2003). This shows the difference in organisational infrastructure between Saudi organisations and organisations in Western countries.

8.2.3 CI initiatives were introduced in private organisations much earlier than in public sector organisations

The results of the survey and case study show a correlation between the sector and the year of introducing Lean/Six Sigma, i.e. Lean and Six Sigma were introduced in private sector organisations many years earlier than in public organisations. This was due to the influence of their joint ventures with Western based organisations or a Western parent company. More specifically, there was a gap of around 10 years between the introduction of Lean/Six Sigma in the two sectors, according to Table 5.2. Lokkerbol et al. (2012) argue that public sector organisations suffer from a chronic inability to change and are less willing to change, due to their bureaucratic structure.

8.2.4 Current status of Lean Six Sigma (RQ1)

The current level of LSS has been assessed through creating a number of theoretical statements to present the key findings from the empirical study and match them with the literature.

8.2.4.1 Lack of LSS awareness across the organisations.

Analysing the current status of LSS in the participating organisations, in general, shows a lack of awareness by participants about the current level of LSS implementation. Many of the participants held LSS belts and had undertaken projects, but they were not aware of the 'bigger picture' with respect to LSS in their organisations, such as the number of trained people, number of completed projects, investment in LSS and financial benefits. They could provide information about what they had done and what they felt but not what other people were doing. This could be as a result of lack of communication and lack of sharing data about what was happening around them. According to Lokkerbol et al. (2012), supporting awareness and improving LSS in any organisation can be through workshops delivered by the LSS team for the shop floor employees, to make them familiar with some LSS concepts, for example, waste or defect improvement. They argue that using LSS games is a productive way to give employees a chance to practice their process in a creative way and measure the improvement.

The empirical study showed that the number of trained employees and the level of training had a direct relationship with the level of awareness (Savolainen and Haikonen, 2007). For instance, in organisation A everyone was trained as a YB, which led to a high level of awareness across the organisation. In contrast, in organisations C and E, there had been no training conducted up to that time, and many employees were completely unaware of what LSS is, and had never heard that their organisation was deploying LSS. Antony et al. (2005) and Harry and Crawford (2004) suggest delivering white belt training for all employees to gain a basic understanding of LSS as a starting point to increase LSS awareness across the organisation. The survey and case study findings highlighted that some organisations with low awareness of LSS had recently included GBs and BBs amongst their employees, who were hired to create awareness and support the deployment of LSS. A similar finding was reported by Savolainen and Haikonen, (2007), where some organisations hired certified BBs to take the responsibility of delivering awareness sessions, as they were trying to address their future level of awareness. However, white belt training did not exist in any of the case organisations. One of the interviewees who was involved in the validity test for the maturity model (refer to Table 7.2), stated, "I cannot think of a company I have visited in Saudi that uses this terminology 'white belt'. From what I have seen Yellow Belt (although varied in what this means between companies) tends to be the entry level training". However, white belt training is well recognised in the West as a basic level understanding for LSS methodology (Bendell, 2006; Laureani and Antony, 2012; Smith, 2003; Snee, 2004, 2010; Taghizadegan, 2006; Voehl et al., 2013).

8.2.4.2 Weak LSS infrastructure across Saudi organisations.

The empirical study revealed that the LSS infrastructures in Saudi Arabian organisations were weak compared to the infrastructure recommended in the literature and Western organisations. Thus, the recommended infrastructure to improve the existing infrastructure in the case organisations is presented in Table 8.1, based on the number of employees in each organisation and as suggested in the literature (Harry, 1998; Voehl et al., 2013). It is recommended that organisations need 1 YB for every 5 employees (Voehl et al., 2013), 4 to 5 GBs for every 100 employees (Ladani et al., 2006; Laureani and Antony, 2012), 1 BB for every 100 employees (Breyfogle, 2003; George, 2003; Harry, 1998; Harry and Schroeder, 2005; Karthi et al., 2011; Laureani and Antony, 2012; Voehl et al., 2013) and 1 MBB for every 15-20 BBs (Voehl et al., 2013). However, Rowlands (2003) argues that LSS can survive without a MBB, where the BBs can report directly to the champion, and that the position of champion is very important for the success of LSS, for successful integration of LSS into the business and to maintain financial benefits in the long term. Nevertheless, Antony et al. (2008) reported that, in a study of SMEs in the UK, 35% of the sample had no deployment champions, which is one of the reasons why LSS initiatives fail to deliver results. This indicates that even in Western countries some organisations have an inadequate infrastructure and are not deploying the recommended infrastructure.

Table 8.1: The recommended infrastructure for the case organisations

Org.	No. of employees	YB		GB		BB		MBB		Deployment Champion	
		R	A	R	A	R	A	R	A	R	A
A	2000	400	2000	100	400	20	100+	1	1	1	1
B	900	180	0	45	0	9	1	0	0	1	1
C	4500	900	0	225	1	45	4	2-3	0	1	0
D	1200	240	20	60	14	12	4	0	1	1	1
E	2000	400	0	100	3	20	2	1	1	1	0

R= recommended number based on literature, A= actual number

In comparison with the recommendations from the literature in Table 8.1, the findings from the case study show a prevalent weakness in the LSS infrastructure in the case organisations. However, the positive point is that the interviewees in all the case organisations strongly agreed on the need to improve the infrastructure to improve their organisations' performance and they recognised that LSS could not be sustained over a period of time with the current infrastructure. As a part of that recognition, organisations B and C planned to send some employees for LSS training, while organisation D was encouraging their employees to start the online LSS training available on the organisation's internal website. Organisation E planned to train 30 employees for YB through an external training institution, but this had still to be approved by the upper management, who had allocated a budget and plan for the training.

It is argued that investment in people is very important because it is investment in the intellectual capital (a form of long term finance) and its benefits are in the long term: for example, employees who have trained for GB may work at the organisation for more than 10 years in the future, so although the organisation has invested the money now, the income generated will continue for the next 10 years.

8.2.4.3 Lack of standardisation regarding duration of training and certification process.

This study investigated the training provided for Lean Six Sigma in different organisations. Table 5.3 compares the training duration and requirements for certification across the organisations studied.

It can be seen that both the duration of YB training and certification requirements vary between the case organisations. Organisation A provided only a 1-day training, with no exam or project required from trainees. In organisation B, YB certification required three days training and a project, but there was no amount of saving per project required as an outcome, while organisation D provided 15 hours online training, followed by an exam. Even in the literature, it has been found that the requirements for YB certification and the duration of the training vary between one to five days, depending on the training provider and training syllabus (Assarlind et al., 2013; Laureani and Antony, 2012; Voehl et al., 2013). There is also a lack of detail in the literature about the tasks that a YB needs to do after certification. For instance, although Voehl et al. (2013) recommend that YBs need to be involved in LSS projects plus their normal daily work, there are no specific tasks suggested that the YB is responsible for as a team member.

Nevertheless, the above findings from the investigation of the GB in-house training in organisations A and D show that their approaches were completely contrary to the methods advocated in the literature, which suggests that a GB needs to receive two weeks of training and needs to execute two projects a year with $25,000 to $50,000 savings per project (Harry, 1998; Laureani and Antony, 2012; Snee, 2010; Wijma et al., 2009). Other organisations had no in-house GB training provided yet, or their employees were trained abroad.

In addition, the BB training duration in organisations B and D (see Table 5.3) was less than four weeks, while organisations A and D asked each trainee to execute only one project with no specific amount of saving to be certified. However, it is suggested in the literature (George, 2003; Harry, 1998; Harry et al., 2010; Hoerl, 2001; Snee, 2004; Taghizadegan, 2006) that, for a BB, there should be four weeks training (a total of 20 days), followed by an exam and a project, prior to certification. In addition, after certification, it is specified that BBs need to work full-time in BB projects and add $500,000 to $1million to annual profits (George, 2003; Harry et al., 2010), whereas this was not the case in the Saudi organisations under study.

It was found that there was no training programme for MBB certification in the case organisations. According to George, (2003), Hoerl (2001) and Snee (2004) , MBBs need to receive two to five weeks training, which was not the case in these Saudi organisations.

The champion position does not require training in all the organisations, because it is based on experience and high skills in LSS project deployment. According to the literature (Harry, 1998; Laureani and Antony, 2012; Smith, 2003; Snee, 2004), champions need to receive from two days to one week of training. Moreover, in organisation A, although the deployment champion's role was more of a management role, the champion still had to complete all the belt levels, i.e. GB, BB and MBB before becoming a champion. Thus, only a MBB can be promoted to be a LSS Champion, after several years of experience (around three years). This system was dictated by the joint venture organisation and adhered to by organisation A. This is not the case in the West, where the champion is often a member of the leadership committee/senior management and it is not necessary to be certified for MBB (Laureani and Antony, 2012; Pande and Holpp, 2000).

The researcher would argue that the Saudi Society for Quality (SSQ) has to take the responsibility to standardise any CI training, based on the country's culture and market needs. At present there are many training institutes available in Saudi which deliver LSS training, most of which certify people for LSS GBs and BBs if they attend the training, and without executing projects. This will lead to a high number of certified people with low practical experience in project implementation.

It should be pointed out that many researchers have called for standardising LSS training and there are suggested standards for LSS certification, proposed by Laureani and Antony (2012). However, the problem is still occurring, although many studies have been conducted in this area. In addition, it was found that the number of completed projects per BB suggested by some scholars is not reasonable compared to the average duration of each Six Sigma project, i.e. six months (Snee, 2010). For example, Harry (1998) states that a BB can complete 5 to 6 projects per year and add $1million to annual profits, whereas Pyzdek (2003) states that a BB can complete 5 to 7 projects per year, working with a team, and Voehl et al. (2013) claim that a BB can work in 2 to 4 LSS teams at a time and complete a minimum of eight projects in two years. However, if one project lasts for 6 months, then a BB can complete only 2 projects a year, which will not generate $1million profit. On the other hand, according to Pande and Holpp (2000) a BB can complete four to eight projects in two years. The author argues that this might be more applicable in the American context, where these studies were carried out.

These conflicting claims indicate that there is no standardisation for BB projects and there are different opinions from different consultants, which leads to a huge research gap.

8.2.4.4 Black Belts are not working full-time in LSS projects.

It is widely advocated in the literature (Hoerl, 2001; George, 2003; Snee, 2004; Taghizadegan, 2006; Laureani and Antony, 2012) that BBs should work full-time in LSS projects and deploy two to three projects a year, which save a minimum of $500,000 to $1million per year (Harry, 1998; Harry et al., 2010; Laureani and Antony, 2012; Snee, 2004). However, despite these recommendations, none of the BBs in the case organisations was working full-time on LSS projects, because they were working on LSS projects in addition to their normal daily work. Additionally, each organisation had different priorities, and it was found that LSS was not the first priority in the case organisations, leading BBs to be involved in tasks other than LSS projects. For instance, in organisation A, BBs and MBBs were involved in the ERP system development, whereas in C, BBs were involved in the academic accreditation process. However, this could be suitable for the Saudi culture. Despite the recommendations in the literature that BBs should be full-time, Nonthaleerak and Hendry (2008) reported that part-time BBs were found to be more realistic for organisations in Thailand, particularly SMEs. The evidence in this study is not sufficient to draw a conclusion about the most applicable BB pattern, which provides an opportunity for future research in this area.

8.2.4.5 Deployment champions have different roles and responsibilities in each organisation.

The results show that not all the organisations had a deployment champion: 19% of the surveyed organisations and two out of the five organisations in the case study had no champions: yet, one of the failure factors for LSS sustainability is lack of champions and their involvement in project selection, project reviews, tackling resistance to change, and finding resources (Chakravorty, 2009; Smith, 2003; Snee, 2004, 2010). Snee (2010) states that one of the success factors for LSS sustainability is the availability of a champion in place to review projects. Thus, LSS success needs a corporate deployment champion to make sure that no obstacles can get in the way during the project execution. Although many scholars have stated that an organisation needs one deployment champion for the LSS programme, both Chakravorty (2009) and Jaideep et al. (2004) suggest that for effective management of operational change, organisations need one champion for every 3 Six Sigma teams. In other words, every department should have a project champion for Six Sigma, reporting to the deployment champion of the organisation (Wiklund and Wiklund, 2002).

Investigation of the role and responsibilities of LSS champions in the case organisations A, B and D showed that champions' roles and responsibilities were not standardised as is suggested in the literature (Hilton and Sohal, 2012; Laureani and Antony, 2012; Mader, 2007; Smith, 2003; Snee, 2004). However, the role of a LSS Champion is varied and diverse, depending on the size of the organisation and the scope of the LSS deployment (Mader, 2007).

The champion in organisation A was responsible for many activities, as suggested in the literature. For instance, the champion was responsible for ensuring the alignment of LSS projects with the organisations' strategic goals, understanding the priorities of the business and translating them into strategic or operational LSS projects, being involved in the development of the business case for LSS projects, development of a LSS project charter, removing roadblocks during the execution of projects carried out by BBs or GBs, and conducting the toll gate reviews. The champion in organisation B also had most of the Lean responsibilities, in terms of selecting projects, guiding the team, selecting employees for training and educating them to deliver the projects, scoping projects, dealing with challenges related to project completion, and attending regular meetings related to project progress and reviews. The deployment champion was also responsible for increasing the awareness of Lean across the business, as well as making Lean the primary catalyst for Continuous Improvement. The champion in organisation D provided guidelines when required, as he also had many other responsibilities, as he was the plant VP and the project sponsor. He was involved in meeting with the CI team at a weekly event, to judge what they had done and what was needed next.

Compared to the findings and recommendations in the literature, the champions in organisations A, B and D were carrying out most of the activities that they should be, although they had a very high workload, due to the weak infrastructure and resistance to change. As organisations C and E had no deployment champions, they both assigned the champion's tasks to the quality assurance department manager, with some assistance from a BB in C and LSS team members in E.

8.2.4.6 Using online training is very effective and flexible.

The parent organisation of organisation D had created the online training package for LSS belts, to save their employees both time and effort. The researcher argues that online training is very effective because it is more flexible than attending classes and needs less effort, although it needs very high motivation and commitment to study all the required course materials. Moreover, using online training is recommended in the literature by Harry and Crawford (2004), for organisations that do not have the ability to send their employees for face-to-face training. Even large American corporations are using online training, such as Xerox, where YB online training was introduced in 2003 (Fornari and Maszle, 2004).

In contrast, Organisation E delivered a 15-minute Lean video to employees as an introduction to Lean, followed by an exam in Lean awareness. The author argues that this video might not add any value to employees, as this teaching approach has never appeared in the literature, plus it was simply suggested by the MBB. Hence, it is one person's point of view and cannot be generalised for other organisations. In contrast, Murman (2011) reported that the Lean fundamentals course in the Massachusetts Institute of Technology lasts for three days.

The author argues that more research is needed to measure the effectiveness of online training for LSS and whether it is better than classrooms with live interaction between trainer and other trainees.

8.2.4.7 DMAIC is the dominant method for LSS, with very basic and simple tools and techniques.

The finding from this empirical study in regard to the most commonly used methods, tools and techniques indicated that DMAIC was the dominant method in LSS projects. Using DMAIC is strongly recommended by LSS scholars (Hoerl and Gardner, 2010; Snee, 2010) and it is widely used in organisations around the world. Its usefulness was obvious in the case studies reviewed in Chapter 2, where DMAIC was used as the main framework to execute projects successfully, with rapid completion and in an organised manner.

Investigating the most commonly used tools and techniques employed under the DMAIC method showed that simple LSS tools and techniques were very common in these Saudi organisations, whereas complex statistical tools did not exist in most of the organisations. Such a lack of use of statistical tools and techniques has been reported in many countries, including the UK (Antony, 2004; Antony et al., 2005; Antony, et al., 2007; Antony and Kumar, 2012), the Netherlands (Akkerhuis et al., 2015; Timans et al., 2012), and Ireland

(Laureani and Antony, 2010). Moreover, it was observed that across different countries, American organisations were more familiar with the use of the Six Sigma toolkit than those in Europe and other countries (Albliwi et al., 2015). However, it is argued here that to reach a higher level of Lean/Six Sigma implementation and to get more benefits from these methodologies, organisations should explore the toolbox more widely and try to use more tools and techniques (Karim and Arif-Uz-Zaman, 2013; Shah and Ward, 2003). Using different sets of Six Sigma tools/techniques can improve the creativity of the employee, and only the creative thinker can find the solution for the problem. Using Six Sigma without selecting statistical tools is not recommended and some Six Sigma projects need both basic tools and statistical tools, depending on the nature of the problem (Timans et al., 2012). On the other hand, Lean tools alone cannot solve all problems, especially when very complicated problems occur (Corbett, 2011).

In contrast, Antony et al., (2007) argue that Six Sigma is not about using a collection of statistical tools/techniques, especially for the service sector, which does not require more than simple problem-solving tools.

8.2.4.8 The DFSS method is limited to manufacturing sector organisations.

When organisations aim to introduce a new product or design a new process, it is more effective to use one of the DFSS methods, such as IDOV and DMADOV (Hoerl and Gardner, 2010). In this study, it was found that DFSS methods were rarely used in Saudi organisations and their use was limited to manufacturing sector organisations. Only 8% of the survey sample stated that they were using DFSS. This is because people in Saudi organisations believe that DFSS is not applicable for service organisations. According to Mader (2003), resistance to DFSS in the service sector is highly expected, because employees in the service sector tend to be non-analytical people, whereas DFSS is an analytical method. Nevertheless, DFSS is widely used in service sector organisations to design new processes/services that improve business results (Gremyr and Raharjo, 2013; Montgomery, 2010).

Moreover, it was found that the organisations that used DFSS were either multinational organisations or organisations engaged in joint ventures with world-class organisations, whereas none of the public sector organisations had yet introduced DFSS. This indicates the importance of collaboration with global organisations to learn new practices. In world-class organisations such as Xerox, the DFSS method is well-recognised and can be used when needed, e.g. to design or launch new products or services, and a study found that 10% of BBs in Xerox were trained in the use of the DFSS method (Fornari and Maszle, 2004).

8.2.4.9 The most common benefits generated from LSS are soft benefits.

The empirical study shows that the most commonly gained benefits from LSS deployment in Saudi organisations were soft benefits, such as increased customer satisfaction, improved employee morale, and changes in employee thinking toward CI, whereas the least common benefits were hard benefits, such as increase in sales, profits or market share, particularly in public sector organisations. The reason for this phenomenon is that these Saudi organisations were highly motivated towards LSS deployment to generate soft benefits. This finding was also reported by Alsmadi et al. (2012), who conducted an empirical study to assess the current status of Six Sigma in Saudi organisations. Ruff, (n.d.) suggests that organisations should consider the value of soft benefits, because such benefits generate additional saving to the organisation, even although they are unquantified.

In the public sector context, Lokkerbol et al. (2012) found that increasing efficiency has high priority in the public sector, as a result of the influence of governmental attitudes and the absence of financial pressures. However, the drive to achieve high efficiency work in government organisations is due to lack of funding, which gives no choice other than to perform more efficiently to reduce expenses. Therefore, measuring project success was more related to process efficiency than bottom-line savings in hard cash.

8.2.4.10 Measuring investment in LSS and ROI is not a priority for Saudi organisations.

The empirical study suggests that measuring the amount invested in an LSS initiative and the financial benefits, e.g. ROI, was not a priority for many Saudi organisations. Many interviewees, including MBBs and BBs, found it difficult to estimate the amount of money invested in LSS to date. Even the finance department in some case study organisations had no figures about investment in LSS, because this was not their responsibility. The LSS department/team had the full responsibility for LSS initiatives.

However, it is very important to measure both the investment and the savings generated from these projects. This is because if an LSS project is implemented to improve a product but the amount invested is unknown, then the product selling price could be less than the cost of production, leading to a loss. Moreover, customers are looking for both value and price, so if the organisation just focuses on quality and neglects the financial aspects, then it will produce a product with high quality but a high price, resulting in loss of customer satisfaction. Six Sigma is based on three elements i.e. Quality, Time and Cost, so if any element is ignored, then the Six Sigma system will be incomplete (Kumar et al., 2009a; Pande and Holpp, 2000). Bisgaard and Does (2009) argue that there are no trade-offs between quality and cost; organisations can improve quality and reduce cost in parallel.

The estimated total investment in Lean and Six Sigma, to the time of this study, was around \$25 million overall in organisation A (approximately \$12,500 per employee since its inception) and \$2 million per year in organisation B (approximately \$2,200 per employee per year). As organisation A had 2,000 employees and organisation B had 900 employees, this amount seems huge compared to expenditure in world-class organisations, especially as organisation A had in-house training, which saved a lot of money for the organisation. This can be compared to world-class organisations: GE introduced Six Sigma in 1996 and invested \$200 million, where the number of employees was 239,000. In 1997, a further investment of \$400 million was made and the employee number was increased to 276,000 (GE, 1997). That means GE invested around \$836 per employee in 1996 and \$1,449 per employee in 1997.

Most of the sample organisations failed to measure ROI from LSS, as shown in Chapters 4, 5 and 6. Watson-Hemphill and Bradley, (2012) found that organisations that have recently deployed LSS have lack of consideration for ROI. They point out that ROI cannot be calculated until organisations have completed a sufficient number of projects; but they suggest a minimum ROI of 10 times the original investment for a deployment to be considered successful (Watson- Hemphill and Bradley, 2012). However, Snee, (2004a, 2010) suggests that LSS can be considered successful in an organisation when return on sales is only 1-2% per year for large organisations and 3-4% for SMEs. Financial benefits can also be measured through financial returns from projects executed by each full-time BB and GB per year, which should be around \$25,000 (Laureani and Antony, 2012) to \$50,000 (Snee, 2010; George, 2003) per GB and \$500,000 (George, 2003) to \$1 million (Harry et al., 2010; Voehl et al., 2013) per BB in each year.

Nevertheless, many organisations are not yet considering the possible financial return they could gain from improvement projects (Schroeder et al., 2008), although Lokkerbol et al., (2012) found evidence that in the Netherlands successful improvement projects were leading to returns on the initial investment. So investment in CI projects is not a waste of money but is long-term investment.

It was observed that three organisations out of five had no figures regarding investment or ROI from LSS projects, although it is essential in Six Sigma to measure the financial impact. It might be suggested that the interviewees were not comfortable in sharing figures for financial results because they were aware of their organisation's weaknesses in terms of financial returns. If organisations do not measure financial returns, this suggests that they are not implementing LSS as it should be: GE, for example, do not have to hide their financial results, in fact they are proud to share them with the world.

8.2.4.11 CSFs in Saudi organisations are aligned with CSFs in other countries.

The empirical study concluded that the top five CSFs for LSS in Saudi organisations are:

1- Training and education.
2- Top management commitment and support.
3- Availability of resources.
4- Project selection and prioritisation.
5- Communication.

These factors were also cited as important for LSS success in other countries, including the USA, UK, Netherlands, India, Malaysia and Australia, as shown in Table 6.3. They were also found to match the factors cited in the literature, as shown in Figure 2.10 (Antony et al., 2003; Chakravorty and Shah, 2012; Hilton and Sohal, 2012; Snee and Hoerl, 2007).

It was observed that supportive and visionary leadership was less cited as a CSF in both the survey and interviews, which indicates a serious deficiency in the role of leadership, especially in changing organisational culture, as shown in Table 5.8. Organisational culture was also not cited as a CSF for Saudi organisations, although it was highly cited in the literature and in particular certain countries, i.e. the USA, the Netherlands and India.

In addition, the top five CSFs cited in the survey were statistically significant when they were examined in the case organisations. It was further deduced that these CSFs are equally important for the case organisations, but the mean practice value was below 4. This indicates that although the participants rated these factors as the most critical success factors for LSS in their organisations, the lack of application of these CSFs in practice may negatively affect the level of organisational performance. The participants believed that, in terms of these factors, more needed to be done to improve their performance.

Two new CSFs emerged from the interview phase, which are rarely cited in LSS literature, namely, the ability to finish projects on time and willingness and motivation of staff to be involved in training and projects. One of the challenges that always faces executives in companies is the time it takes for LSS project implementation (Pepper and Spedding, 2010; Richard, 2008; Smith, 2003). Snee (2010), argues that the implementation of LSS projects should not take more than three to six months, and this is one of the characteristics that differentiate LSS from other improvement initiatives. However, it is unclear whether this refers to YB, GB, BB or MBB projects. In the interviews, the willingness and motivation of staff were also identified as critical to the success of LSS initiatives in some Saudi organisations. In contrast, respondents in organisation A reported that it was very challenging to get everyone involved and interested in LSS projects.

8.2.4.12 Challenges for LSS implementation

According to the survey and interviews, the top challenges for LSS deployment that Saudi organisations most commonly face are:

1- Internal resistance.
2- Time consuming.
3- Lack of a project selection system.
4- Lack of awareness of statistical methods, tools and techniques.
5- Lack of physical resources (manpower).

These factors were slightly aligned with the findings from the literature in Chapter 2, Table 2.7 (Chakravorty and Shah, 2012; Pepper and Spedding, 2010; Thomas et al., 2009, 2014; Timans et al., 2012). Although project selection and prioritisation was cited as a top CSF for LSS in Saudi organisations in the survey and interviews, it was also cited as a top challenge for the participating organisations. This indicates that the organisations were still facing challenges to select projects and much improvement would be needed in the project selection process. The root cause for this challenge was the lack of LSS project champions, who have a critical role in the project selection process (Chakravorty, 2009; Smith, 2003; Snee, 2004, 2010). Some challenges that emerged from the interviews were:

1- The way of carrying out projects under DMAIC phases in organisation A was slightly different to what it is supposed to be and what was delivered in the training. One example was that the LSS team worked with other departments on LSS projects until the Improvement phase, where the BB provided the solution and expected the process owners in those departments to lead the control phase and implement the suggested solution. Unfortunately, in some cases there was no follow up from the process owner and sometimes changing the personnel in the department or changing the process owner could prevent the improvement, because there was no handover for the Six Sigma project. The LSS team also struggled to know when the project should go from one phase to another, what were the checkpoints and what were the important points to measure. This could be not only as a result of lack of experience in using DMAIC, but also due to DMAIC's inherent limitations (de Mast and Lokkerbol, 2012; Qi et al., 2013). For instance, DMAIC methodology was criticised by Nonthaleerak and Hendry (2008) for its weakness in the define and control phases, leading Six Sigma projects to fail, and this is exactly what occurred in some projects in Saudi organisations. The researcher argues that in order to tackle this challenge, more control is required from the process owner during the control phase, e.g. some kinds of control charts can be used to monitor the process and identify particular causes of variation. Nonthaleerak and Hendry (2008) also argue that the control phase is very critical for Six Sigma effectiveness and sustainability.

2- The difficulty in getting everyone involved and interested in LSS projects. This could be due to lack of a reward and recognition system for LSS teams for their achievements (Albliwi et al., 2014; Worley and Doolen, 2006). Lack of motivation, such as a financial reward, leads to another challenge, which is losing experts who find better job opportunities in other organisations, which in turn leads to lack of experienced people in the organisations to take the responsibility of leading the LSS initiative, and finally the whole initiative can fail, as shown in Figure 8.1.

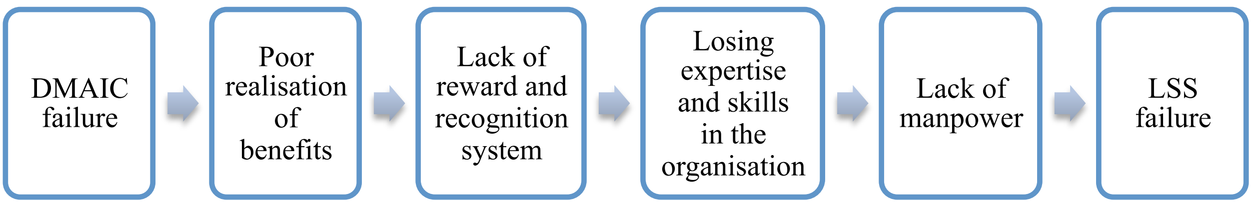


Figure 8.1: The effect of DMAIC failure on an LSS initiative

8.2.4.13 Impacts of organisational culture and leadership on LSS

The researcher argues that there is a strong relation between culture and leadership, as a visionary leader can create a positive culture for CI and create a sustainable CI culture (Salah et al., 2010). This can be evidenced in organisation A, which had very supportive and visionary leadership who had contributed to changing the culture. This finding is not unique for organisation A but has been discussed by various authors in the literature (Arthur and

George, 2004; Snee, 2010; Corbett, 2011; Laureani and Antony 2012; Salah et al., 2010) who argue that LSS requires a supportive and visionary leader who enables an organisation to bring about change in the way it carries out its work.

On the other hand, changing the organisational culture is a big barrier for LSS implementation, especially in the public sector (Antony and Kumar, 2012). Leaders in the public sector understand that it is difficult to implement LSS in the public sector in Saudi Arabia, due to the prevailing culture and resistance to change, which hinder the progress of CI. The main obstacles facing Saudi organisations in shifting the current culture into a supportive culture are individual's mindsets and the blame culture, and these factors were highly cited in the interviews as common barriers to LSS. This finding matches the findings reported by Antony and Kumar (2012) in a study of the National Health Service (NHS) in the UK, which suggested that most of the barriers to LSS are people-based. As a starting point for changing the culture in public sector organisations, Antony and Kumar (2012) suggest delivering a one-day workshop covering the management aspects of Six Sigma and the expected challenges. The interviewees in this study argued that the top management have an important role in changing the culture and making sure that employees' attitudes are favourable towards the CI initiatives. The culture should also be flexible and positive enough to accept people regardless of their countries of origin and different cultures, especially for Saudi organisations, which have employees from many different cultures and nationalities.

Leadership style in Saudi Arabia is different from than in Western countries, due to differences in culture, and what is fit in the West may not be appropriate for other countries in the Middle East (Bjerke and Al-Meer, 1993). In this study, the survey results show that, although lack of leadership was cited in the top challenges for LSS, leadership was not cited as a top CSF for LSS, either in the survey or interviews. It was observed that people are confusing leadership with management commitment and thus there were no clear roles for each of these, although there are many research papers focusing on Saudi Arabia which show the importance of the leadership role in improving organisational culture and creating a creative work environment and also highlight how leaders are different from managers (Al-Beraidi and Rickards, 2003; Bjerke and Al-Meer, 1993; Drummond and Al-Anazi, 1997; Nafei et al., 2012). According to Nafei et al. (2012), lack of leadership in Saudi organisations is due to lack of criteria for selecting administrative leaders. For instance, Nafei et al. (2012) suggest that leaders should be selected for qualities such as their excellent interpersonal skills, ability to inspire employees to carry out their tasks and ability to recognise employees' needs (Nafei et al., 2012). They add that, on the other hand, leaders themselves face many challenges, such as resistance to change and, in some organisations, an unsupportive culture and unclear visions that cause leaders to struggle to convert vision into actions. This study supports the findings of Nafei et al. (2012), while adding the finding that one of the main reasons for lack of leadership was lack of leadership training.

8.2.4.14 The number of LSS projects is very low compared to the years of deployment.

The empirical study shows that the number of projects executed in the participating organisations was very low compared to the years of deployment and the number of trained employees. According to the literature, the number of projects and the saving should be calculated in regard to the number of employees and number of certified GBs and BBs (Harry, 1998; Voehl et al., 2013). For instance, if the organisation has 1,000 employees, it should have 50 GBs, who implement a total of 100 projects a year, with total saving of $2.5 million to $5 million. This organisation also has to have 10 BBs who implement a total of 20 to 30 projects a year, with total saving of between $5 million and $10 million per year.

It was observed that the main reason for lack of project execution was that each organisation had different priorities, other than LSS, as explained earlier in section 6.7. Other reasons were the long duration of LSS projects (up to one year), lack of trained personnel and unavailability of data. Moreover, this study found that it was normal for organisations to have no figures about the number of completed projects. This included some LSS team members who had no evidence about the number of projects completed across the organisation.

According to the literature, (Snee and Hoerl, 2005: Wijma et al., 2009 and Akkerhuis et al., 2015) the duration of a Six Sigma BB project is six months, if the project is scoped, carefully planned and follows DMAIC as a framework. Akkerhuis et al. (2015), Snee (2010) and Snee and Hoerl (2005) all argue that it is critical for organisations to use an effective system to manage and select the project, where this system can guide and sustain the initiative by tracking the implementation process of LSS projects, including project reviews, training, communication and rewards. Using such a system can guarantee LSS project deployment with no obstacles.

The interviews showed that there was inconsistency in the project selection and prioritising tools in the case organisations. Each organisation used its own criteria to select and prioritise projects. However, it was common to select projects that would enhance process efficiency or contribute to solving problems, particularly problems on the shop floor. This clearly shows that these projects were not strategic in nature. Timans et al. (2012) suggest that a system for project selection and prioritisation should be designed in each LSS company. This system should take into account the different types of projects and choose the right people and the right tools for the project. The most appropriate project is the one with the most potential benefits to the bottom-line (Snee, 2010), creating value for customers and fitting in with the available resources and schedule (Zinkgraf and Snee, 1999). Organisations also can use tools for project selection and prioritisation, such as QFD, Kano analysis, Pareto analysis, Project ranking matrix, Project selection matrix and many others (Banuelas et al., 2006; Kornfeld and Kara, 2013).

Another observation in this study was that some organisations did not differentiate between GB projects and BB projects. They had recorded the total number of completed projects but in all projects they worked as a team of one BB, together with GBs and YBs. Thus, when they were asked to specify the numbers of GB projects and BB projects, there were no figures available. According to the literature, there are major differences between BB and GB projects. BB projects should have a major impact on important areas for competitive advantage, such as quality, throughput, cycle-time and yield (Ingle and Roe, 2001), while GBs carry out smaller projects in their own work process on a part-time basis. Rasis et al. (2002, p.128) explain the scope of BB and GB projects in detail:

"Green Belt projects do not deal with political issues, do not require many organizational resources, do not require significant capital investment to realize the gains identified during the project, and utilize only basic statistical methods. On the other hand, Black Belt projects tend to deal with more complex situations that may involve two or more CTQs, may involve substantial political issues, or are cross-functional in nature, require substantial organizational resources, may need substantial capital investment to realize the gains made during the project, and utilize sophisticated statistical methods. Candidates for Green Belt training are individuals who are able to dedicate approximately 25% of their time to project work. Often the project work is focused on processes within or related to the area in which they currently work. Ideally Black Belt candidates are those who will be able to dedicate 100% of their time to Six Sigma projects".

8.2.4.15 No sharing of information about failed projects.

It was very challenging to collect accurate data in regard to the number of the failed projects in the participating organisations. This was due to a lack of data recorded about the history of failed projects. Albliwi et al. (2014) argue that sharing data about failed projects is not preferred, because showing failures could affect an organisation's reputation in the market, so they could lose their customers and reduce market share. However, the most common failure factors for LSS projects highlighted in this study were:

1- Lack of top management commitment and involvement.
2- Lack of physical resources.
3- Copying other organisations' deployment strategies.

These findings were strongly aligned with those in the literature (AlAmin and Karim, 2013; Albliwi et al., 2014; Antony et al., 2012b; Arumugam et al., 2013; Thomas et al., 2009, 2014) (see Table I.5 in Appendix I). Although top management involvement and commitment and availability of resources have been recognised as top CSFs for LSS in Saudi organisations, some participants stated that lack of these factors leads some projects to fail, especially in the early stages of LSS deployment in the organisation (Aboelmaged, 2011; Snee, 2010).

8.2.4.16 The role of HR and IT in LSS has been ignored in most of the organisations.

The participants were fully aware of the important role of HR for LSS success and conversely, the positive impact of LSS on HR performance; yet, this was not obvious in all organisations, and participants from organisation E reported that the HR department was inhibiting the progress of LSS. However, some organisations stated that their HR department had a major role in developing and maintaining a reward policy in relation to LSS. It had also helped to build LSS infrastructure by developing a policy for employee training and recruiting LSS staff. Antony and Banuelas (2002) and Salah et al. (2010) argue that it is essential to link HR with LSS to enable the HR reward system to reward LSS members for their efforts and provide support for the implementation of successful LSS projects. Moreover, the belt system in LSS provides a systematic training framework, which is useful for human resource management (Antony, 2012).

Investigating the role of IT in regard to Lean/Six Sigma shows that this role was absent in all the participating organisations, except in organisation A, where IT had a minor role and had been involved in very limited projects. This could be due to lack of communication or lack of understanding of the important role of IT in the success of LSS projects. Both Antony (2012), and Sehwail and DeYong (2003) argue that IT resources are necessary to track Six Sigma projects and enhance the applicability of LSS. IT experts work with the LSS team to support the process (Anand et al., 2010), streamline the processes, and eliminate redundant data entry (Furterer and Elshennawy, 2005). According to Svensson et al. (2015), “The primary objective of the IT department is to enable organization-wide business processes”. They also argue that a successful LSS programme needs support services such as Administration, Finance, HR and IT to be efficiently organised. According to Snee (2010), poor support from HR and IT is considered as a common mistake made by organisations deploying CI initiatives.

Moreover, in the participating organisations, the impact of LSS on these two departments (HR and IT) was very low compared to other departments, such as customer service, the administration process and production process.

8.2.5 Motivational factors for LSS deployment (RQ2)

According to the survey and interviews, the top motivating factors for organisations to deploy LSS in Saudi organisations were:

1- To improve product and process quality;
2- To improve process efficiency and effectiveness;
3- To reduce time (cycle time, lead time, etc.);
4- To increase customer satisfaction;
5- To enhance business sustainability.

From the list above, it can be observed that improving products and process quality and improving efficiency are the top motivations for Saudi organisations to implement LSS, while financial benefits such as enhancing the bottom-line are not in the top five factors. Nonthaleerak and Hendry (2008) report similar findings in their Thailand-based study, showing that some organisations place less emphasis on financial savings, because quality and efficiency are the main priorities. In contrast, the reduction of cost and obtaining financial benefits are the main priorities in several other countries, as presented in Table 6.5. The author argues that, although some organisations stated that their top motivation for LSS deployment was to reduce defects and reduce cost, while they did not consider financial savings as a top motivational factor for LSS deployment, in practice, the reduction of defects will lead to financial saving and also reduction of operational cost will result in financial saving, as evidenced in many case studies (Corbett, 2011; Roth and Franchetti, 2010; Wijma et al., 2009; Zu et al., 2008). Nevertheless, Linderman et al. (2006) argue that some projects could generate strategic benefits that cannot be financially quantified i.e. zero financial saving.

One motivating factor that emerged in this study was the pressure from the joint venture organisations or the foreign parent organisations to deploy CI initiatives in order to be aligned with other organisations across the globe and generate more benefits, e.g. increasing sales and market share and improving the quality of products/services. Many large corporations have created joint ventures with similar corporations in the business, such as the joint venture between Mitsubishi and Volvo in the automotive industry, to share the success of Lean. This joint venture has resulted in increased production efficiency and improved employee morale (Pepper and Spedding, 2010).

Authors such as Lewis (2002) have reported many benefits gained from Six Sigma deployment under the control of a multinational joint venture organisation. These include improving the process quality, mapping the activities, training people for LSS belts and obtaining unique results. Furthermore, organisations in developing countries have realised that foreign-owned or joint venture companies are pioneers in quality management and CI, while local organisations look towards improving quality through collaboration with multinational organisations (Krasachol et al., 1998; Magd and Curry, 2003).

Investigating the participants' motivation to be involved in LSS projects and training showed that they all had intrinsic motivation but extrinsic motivation (financial motivation) was rarely present. According to the literature, financial reward is highly motivating to LSS team members and increases their motivation towards taking part in future LSS projects (Jeyaraman and Teo, 2010; Snee, 2010). The interviewees also argued that if people received financial reward, it would be a very strong motivation for them to work harder and hence increase the organisation's performance and achieve better results. They expressed the belief that all MBBs and BBs who work in Six Sigma projects and make savings have the right to receive a percentage of that saving, which was not currently applied in most of the participating organisations.

Snee (2010), Jeyaraman and Teo (2010), Salah et al. (2010) and others consider reward and recognition as main elements of the LSS deployment plan. Moreover, Snee and Hoerl (2003) and Jeyaraman and Teo (2010) found a positive relationship between rewarding people and changing the culture. Snee (2010) also found a positive relationship between rewards and the sustainability of CI initiatives. Worley and Doolen (2006) also suggest rewarding employees for their effort and role in the successful deployment of a new programme such as LSS. A Lean practitioner in organisation B stated that recognition for Lean project team members had been discussed with the finance and HR departments, but the mechanisms had not yet been identified to reward employees. This was likely to take time, due to the lack of measurement of financial returns from Lean projects (Salah et al., 2010).

In contrast, another viewpoint is that motivating a CI team is not only through financial reward, which is a part of the extrinsic motivation, but can be through other, intrinsic, types of motivation, such as respecting the voice of employees, letting them know that they are trusted by their managers, communicating failure and success to them, and involving them in review meetings, project improvement teams, training and development (Dahlgaard and Dahlgaard-Park, 2006; Gitlow, 2009; Kumar et al., 2006; Snee and Hoerl, 2003). Moreover, lack of trust between leaders and employees can even negate the value of a financial reward system and eliminate the employees' intrinsic motivation (Dahlgaard and Dahlgaard-Park, 2006). It was found in this study that the approach to motivating the LSS team in the participating organisations was aligned with the second viewpoint, which is more concerned with human recognition than financial reward.

8.2.6 Simple organisational learning practices are adopted to support LSS implementation (RQ4)

The empirical study shows that only simple organisational learning practices were adopted, compared to the wide range of practices suggested in the literature. A wide range of learning practices was never used, such as learning from competitors, and learning from failure, mistakes and incidents. Blame culture could be seen when failure occurred, but the failure had not been used as an opportunity for learning and improvement, especially in public sector organisations. The positive point is that the participants demonstrated a good level of knowledge about the importance of learning, particularly the people who had trained for LSS. For instance, in organisation B, the Lean team was planning to change this negative thinking and trying to use failures as learning opportunities, through problem solving mechanisms. Therefore, it is clear the organisation has to go through long processes in order to improve the organisational learning level. In organisation C, a BB strongly recommend delivering courses in problem-solving techniques, to educate people on how failure can be an opportunity for improvement. In organisation E, a GB argued that using presentations and reports after a project's implementation was not enough to distribute learning practices. He believed there should be an assessment to find all the problems that faced the project and make recommendations for future projects. The assessment could help the team to identify the positive and negative points from this experience. Organisation A used a database of LSS projects to share best practices, as recommended in the literature, e.g. in Gitlow and Levine (2004). Organisation D has applied the 'learning by doing' technique, which is a valid method for organisational learning, as reported in previous studies (Arumugam et al., 2013; Easterby-Smith and Lyles, 2011; Manville et al., 2012). Using the PDCA cycle is considered in the literature as a learning practice and a structure for sustaining learning, because it aims to search for improvement opportunities and commitment to learning (Savolainen and Haikonen, 2007). However, as reported in section 6.5, none of the organisations had considered the PDCA cycle as a source of learning with LSS.

Moreover, the type of learning which occurred in the participating organisations was single-loop learning, where the same mistake could occur several times without fixing the source of the error. This could be due to lack of training and lack of skilled personnel who can make a decision to fix the source of errors in the process. In public sector organisations, bureaucracy and centralising decision making in the top management can delay the change in the process, as was observed in organisations C and E. In the field of Lean and Six Sigma, single-loop learning tends to be more popular than double-loop learning, as cited in many studies (Knowles, 2011; Lagrosen et al., 2011; Savolainen and Haikonen, 2007). Knowles (2011) argues that Six Sigma projects have more focus on quick fixing of problems and generating financial benefits, which reduces the learning option to single-loop learning. Savolainen and Haikonen (2007) think this is still technically a form of the learning organisation, as it is an "incremental change process". In contrast, Antony (2004) believes that in equipping staff with the skills and tools they need to analyse challenges and provide solutions, Six Sigma "encourages the development of learning capabilities" .

It was found that none of the case organisations had achieved the level of a learning organisation, which 'learns how to undertake the experiment better the next time', which is the level needed for complete implementation of LSS (Hines et al., 2004, p.1005).

8.2.7 Using maturity models to assess LSS deployment level is not common in Saudi organisations (RQ3).

One of the key findings of this study is that organisations in Saudi Arabia are not familiar with maturity models for CI initiatives, including Lean and Six Sigma. This can be evidenced in organisation A which had been using Six Sigma for 10 years and Lean for five years and still had no maturity model for either of these methodologies. Participants argued that they were using simple techniques to measure success, such as the number of completed projects, years of deployment, and improvement of the quality of the output. However, an appropriate model for assessing the maturity level of LSS in Saudi organisations, or at least in developing countries generally, was missing in the literature and in practice, as shown in Chapter 7.

World-class organisations such as GE, Xerox, Instantis software, Bechtel, George Group and others have developed their own models based on their business needs and the important activities they want to measure. However, most of those organisations did not publish their models nor share them with other organisations, due to confidentiality and privacy issues. Other organisations, such as Motorola, Tata Consultancy Services (TCS), Honeywell, PS&J Software, and others have integrated Six Sigma/LSS with CMM/CMMI to measure their Six Sigma/LSS maturity level (Shere, 2003). However, it was not useful for Saudi organisations to use any of the available models, such as CMM or CMMI, because these models are very advanced and complicated and it is important to note that what works for one organisation may not be successful in another (Watson- Hemphill and Bradley, 2012). Therefore, it was essential to develop a model that was carefully designed and customised for Saudi organisations. Thus, the model developed in this study has some differences from the models that exist in the literature. Although the model was built on these previous models, it needed to be modified slightly in terms of elements concerning leadership, training, financial benefits and infrastructure. The maturity model developed in this study was used successfully to assess the current level of LSS maturity in the case organisations, as presented in Chapter 7 (section 7.9).

8.3 Chapter summary

This chapter has critically discussed the key findings of the empirical research and compared the results to the literature. The discussion was based on a number of statements that were observed during the empirical study. This chapter has provided a deeper exploration of many issues that were raised during the survey and interview phases. This gives a deeper insight into the current status of LSS across the participating organisations, as well as the reasons behind the slow pace of progress of LSS in Saudi organisations. It was observed that most of the organisations were employing LSS as a short-term strategy for problem-solving, although they also stated that they were interested in LSS and had future plans for improvement.

The next chapter is the closure of this research and will focus on addressing the main research questions and will also discuss the contribution of this research to knowledge, theory and practice.

CHAPTER NINE

Conclusion, Contribution to Research and Agenda for Future research

9.1 Introduction

This chapter is the closure of this research and it proposes answers for the main research questions that emerged in Chapter 1. This chapter discusses the quality of the research and presents the main contribution of this study to theory, knowledge and practice. The limitations of this study are also presented, followed by an agenda for future research that can help other researchers in the field to direct their research focus to narrow the gaps in the current literature. Lastly, the critical reflection on the research journey is presented, to show the practices learnt and the personal experiences that the researcher gained, as well as the challenges and barriers faced during the PhD journey.

9.2 Critical reflections on the research questions

The main objectives of this study were to assess the current level of Lean Six Sigma implementation within Saudi Arabian organisations, to gather more evidence about the motivational factors for LSS deployment in Saudi Arabian organisations, to assess the maturity level of LSS in Saudi Arabian organisations by developing a maturity model designed specifically for Saudi organisations, based on the literature review and empirical study, and finally, to assess the extent to which the participating organisations can be described as learning organisations.

To achieve these objectives, four research questions were formulated in Chapter 1 (section 1.4). This section aims to address the main research questions, based on the research findings.

RQ1: What is the current level of adoption of Lean Six Sigma in Saudi Arabian organisations?

The aim of this question was to investigate the current level of LSS implementation in Saudi Arabian organisations. This was through the investigation of many characteristics and themes derived from the literature, which were then investigated in the sample organisations, through survey and interview techniques. The results show that CI initiatives, and Lean Six Sigma in particular, are in the early stages of implementation and organisations in Saudi Arabia have only recently started to recognise the importance of LSS to their business (Alsmadi et al., 2012). Although Lean and Six Sigma were introduced to private sector organisations many years before public sector organisations, the implementation level is still at the beginning in both sectors. In addition, it was concluded from both the survey and interviews that LSS deployment was greater and better established in international than in local organisations, probably due to the influence of their parent companies, which have a long history of LSS implementation. Nonetheless, it was found that CI initiatives were not sustained for more than three years in some of the sample organisations, due to management change and organisational culture. The negative effect of organisational culture and the resistance to change from senior employees is always a major barrier for Lean and Six Sigma to be successful in Saudi organisations. The benefits generated from Lean and Six Sigma were mostly soft benefits, whereas hard benefits were rarely generated.

Thus, there is still room for improvement across these organisations in terms of training and infrastructure, project selection, using advanced statistical tools and techniques and focusing on financial benefits. Therefore, it appears that organisations in Saudi Arabia have quite a long way to go before they can make LSS the way of doing business. This will need collaboration across the entire organisation, with strong support and commitment from the senior management.

All the participants wished to integrate LSS into all the business functions within their organisations in the future, for greater competitive advantage and achieving operational and service excellence, especially with the pressure that comes with Foreign Direct Investment in Saudi Arabia.

RQ2: What are the motivational factors for Lean Six Sigma deployment in Saudi Arabian organisations?

According to the empirical study, the motivational factors identified as most common for LSS deployment in Saudi Arabian organisations were to improve product and process quality, to improve process efficiency and effectiveness, to reduce time (cycle time, lead time, etc.), to increase customer satisfaction and to enhance business sustainability, while generating financial benefits was not highly rated as a motivational factor. However, improving quality, efficiency and customer satisfaction will lead to less rework and less employee overtime and hence, financial saving can be generated. The motivating factor that emerged in this study is the pressure from the joint venture organisation or the parent organisations in Western countries, which were insisting on the adoption of LSS to conform to global expectations.

Comparison of the motivations for deploying LSS and the benefits gained shows that Lean, Six Sigma or LSS had been introduced to achieve specific goals, and that, on the whole, not all of these goals had been achieved. In fact, these goals may be achieved in the long term by executing more projects and delivering training for more people across the organisation, especially for those organisations that are deploying LSS to improve the organisational culture, which cannot be changed in a few years but needs many years, as pointed out by Toyota.

The personal motivation of people to undergo training for LSS belts and be involved in LSS projects shows that intrinsic motivation is the dominant type of motivation in an LSS team, whereas extrinsic motivation (financial motivation) was not found to be the main motivator. Nevertheless, participants stated that they would appreciate financial reward, which would give them more motivation to work harder and hence increase the organisation's performance and achieve better results. They were fully aware of their right to receive a percentage of the savings generated from LSS projects, which was not currently applied in most of the participating organisations for many reasons, such as the lack of financial benefits in some projects, failure to actually calculate financial benefits gained and lack of a reward system, such as in the public organisations sector.

RQ3: How can the maturity level of LSS in Saudi Arabian organisations be effectively assessed?

In order to assess the current maturity level of LSS in the participating organisations, it was essential to find a LSS maturity model that was specifically developed for organisations in Saudi Arabia, or at least for developing countries. Unfortunately, there was no literature on such LSS maturity models. Hence, to answer this research question, the researcher developed a maturity model based on a systematic review of the available models in the literature for business process improvement (Bessant et al., 2001; Bessant and Caffyn, 1997; Crosby, 1979; OMG, 2008; SEI, 2000) and Lean and Six Sigma (Li and Lin, 2011; Malmbrandt and Ahlstro, 2013; Watson-Hemphill and Bradley, 2012; Zhen, 2009). The second step was to interview the potential users of the model in Saudi organisations about their opinions and suggestions that might help in developing the maturity model. A conceptual model was then developed (setting out capability levels, characteristics and scoring criteria) based on the literature, interviews and unpublished maturity models from world-class organisations. This was followed by interviews with experts and practitioners in the field in Saudi Arabia for validation of the developed model. The feedback was obtained and the model was refined and, finally, the model was pilot tested in five Saudi Arabian organisations to assess the level of LSS maturity, based on their score against the five levels of maturity. The results show that none of the case organisations was found to have reached the world-class level, even the multinational organisations and those local organisations that were in joint ventures with other organisations in Western countries.

RQ4: To what extent can Saudi Arabian organisations participating in the case study be considered as learning organisations in the context of Lean Six Sigma?

The empirical study shows that only basic organisational learning practices were available in the sample organisations (most likely in private sector organisations). These practices included sharing knowledge and experience of LSS deployment via databases, knowledge networks, regular meetings, communication boards, daily e-mails, presentations, open discussions and reports.

However, little evidence of learning from failure, mistakes and incidents was available. Finally, with regard to learning from the joint venture organisation and parent organisation, even though the private sector organisations had learning input from their joint venture partners/parent organisation, organisational learning practices remained basic. Learning organisation practices such as continuous learning, practice of learning in daily life, supportive learning environment, creating a culture of learning had not yet been achieved to the degree needed for a complete implementation of LSS in the sample organisations (Lagrosen et al., 2011). Although benchmarking is a great opportunity to learn from others and bring about change to achieve competitive excellence (Freytag and Hollensen, 2001), it was not common in the sample organisations. Furthermore, the learning curve technique was never used to measure organisational learning in the sample organisations.

Therefore, it is too early for Saudi Arabian organisations to be described as learning organisations, where there are five core disciplines in building a learning organisation, which are 'systematic problem solving, experimentation with new approaches, learning from their own experience and past history, learning from the experiences and best practices of others, and transferring knowledge quickly and efficiently throughout the organization' (Garvin, 1993). It can be concluded that single-loop learning, 'incremental learning', where the same mistake could occur several times without fixing the source of the error, is more common in the sample organisations than double-loop learning, 'radical learning'. This was as a result of the absence of effective action to correct mistakes occurring in LSS projects (Argyris and Schon, 1978; Lagrosen et al., 2011).

9.3 Quality of the research

The criteria for judging the quality of operations management research were presented in Chapter 3 (section 3.6.6). This section presents the research quality criteria for this research, including the quality of the survey and interviews. An overview of these criteria and how they were used is provided in Table 9.1, below.

9.3.1 Research quality criteria for survey research

In this research, the reliability and validity of the instrument was ensured as follows:

1- Content validity: an extensive review of the literature was used to design the questionnaire. The questionnaire was then sent to 15 Lean/Six Sigma academics and practitioners in Saudi Arabia, who were asked to give comments on the survey instrument, and an opinion on the questions in terms of their content, clarity, language, missing points, technical problems and their ability to answer the main research questions. The feedback from this activity was then used to improve the questionnaire; for example, some questions were reworded, or regrouped, changing the order of the questionnaire, and some questions were found to be not related to the research objectives and were deleted. Therefore, the content validity of the survey was ensured.

2- Construct validity: Construct validity is not required when the survey instrument does not use multiple-item measurement scales (Forza, 2002; Rungtusanatham et al., 2003). Thus, the construct validity test was not required in this study due to the limited number of multi-item questions in the survey instrument.

3- External / Criterion validity: this was ensured in the analysis phase by comparing the LSS level in Saudi organisations against LSS characteristics derived from the literature.

4- Reliability: Cronbach's α (alpha) test was used to indicate the survey reliability. Reliability was ensured through piloting the survey questionnaires with 15 Lean/Six Sigma experts (14% of the main sample) who were working in Saudi Arabian organisations which had been implementing LSS for a couple of years. The result of the Cronbach test was higher than 0.70 for all the survey questions, which was considered sufficient and indicates that the survey is reliable enough (Forza, 2009). Moreover, the adoption of survey questions from previous empirical studies, such as those of Antony (2004), Antony et al. (2005) Arumugam

(2015), Kumar (2010), and Kumar et al. (2009b), contributed to ensuring the instrument reliability. According to Saunders et al. (2007) this helps to ensure consistency of the findings, even when the test conditions are different.

9.3.2 Research quality criteria for case study research

In this study, research validity and reliability have been ensured as follows:

1- Construct validity: this has been increased by using multiple sources of evidence for data collection, including the organisations' annual reports, websites, publications and brochures. The semi-structured interviews were conducted with employees from different levels of the organisational hierarchy (refer to table 3.3). Writing the case study report and submitting it for review by experts also contributed to increasing the construct validity of the case study.

2- Internal validity: this was ensured in the analysis phase by conducting pattern matching between cases and trying to find similarities and differences across the 5 cases through the cross-case analysis technique (Voss et al., 2002). Using cross-case analysis can increase the internal validity of the findings, according to Voss et al. (2002).

3- Reliability: this was ensured through the use of a case study protocol and case study database to increase the reliability and validity of the case study method, as suggested by many authors (Eisenhardt, 1989b; Voss et al., 2002; Yin, 2003a, 2014). The case study protocol was developed based on the guidelines suggested by Brereton et al., (2008), Easterby-Smith et al., (2012), Eisenhardt (1989a), Saunders et al., (2009) and Yin, (2003a, 2003b, 2014). In this study, the protocol and the semi-structured interview questions were developed from the findings of the first and second phases of the study (see figure 3.2). This included information on the purpose of the case study, outlines for the subjects to be covered during the interviews, the interview protocol and interview themes, questions to be asked, the required data and data analysis techniques (see Appendix III.1). The protocol in this research was continuously changed and updated as a result of changes in the case study plan. The protocol was reviewed by academics and they were asked to give feedback, in order to ensure that the researcher had covered all the important data to answer the research questions and achieve the aim of the research. They also were asked to ensure that the interview questions were related to the research questions.

4- Generalisability/external validity: generalisability of the findings was ensured by conducting multiple cases to replicate logic, enhance external validity and minimise researcher bias (Voss et al., 2002; Yin, 2003a). The validity was also confirmed by triangulating the findings from the case study with the survey findings (Gable, 1994).

Table 9.1: Summary of survey and case study quality

Test	Survey	Case Study	Phase of research
Construct validity	Not applicable	-Use multiple sources of evidence (interviews, company annual report, website, brochures and presentations) -Establish chain of evidence e.g. the case study themes were developed from an extensive review of literature -Review case study report by the interviewees	Data collection
Internal/content validity	-An extensive review of the literature used to design the questionnaire -Questionnaire was revised by experts	-Use pattern-matching -Use logic models -Use data display	Data analysis
External validity	-Compare and contrast the LSS level in Saudi organisations against LSS characteristics derived from the literature	-Use replication logic in multiple case studies - Triangulating the findings from the case study with the survey findings	Research design and analysis
Reliability	-Cronbach α (alpha) is 0.762 higher than 0.70 indicating the reliability of the questionnaire -Adoption of survey questions from previous empirical studies	-Use case study protocol -Cross-case analysis -Case documentation and review -Develop case study database	Data collection

(Sources: Forza, 2002; Yin, 2003b)

The quality of the LSSMM was ensured from the early stages of the model design and development through involving a number of LSS experts from the early stages of the development of LSSMM artefacts, during the data collection process, and after the model was developed. The model was also based on a systematic review of the available models in the literature, reviewing world-class organisations' maturity models (unpublished), and using experts' suggestions for further improvement and validation (14 practitioners, academics and experts from Saudi Arabia). The model then was used to assess the level of LSS maturity in five organisations in Saudi Arabia (the sample organisations used in the case study were used again for this assessment).

Overall, the researcher has tried to ensure that the most reliable and high quality results were used to answer the four research questions that were developed in Chapter 1. This involved defining the most suitable research methodology and establishing the quality of the research output from the criteria and assessment procedures described in Table 9.1. The researcher was also able to further establish the soundness and quality of the research approach through research methodology courses undertaken and also by attending academic conferences, in particular through discussions with leading academics at a series of symposia in doctoral research methods (provided by Strathclyde university).

9.4 Research contribution

Research contribution is a very essential element in doctoral research (Easterby-Smith et al., 2012). Good research needs to have some link to theory and make a significant original contribution to knowledge and practice (Karlsson, 2010). The contribution of the research can be through publishing and presenting the research output in articles in recognised professional academic journals (Karlsson, 2010) (refer to the list of publication on page iv). This research provides value to academics, practitioners of LSS and those researchers who are involved in CI research. It also gives recommendations to guide the future use of LSS in Saudi organisations by making a comparison with the LSS literature and best practice. In addition, it has highlighted many gaps in the current literature and by developing an agenda for future research it will save time and effort for readers looking to research topics within LSS. This research has also made a contribution to operations management theory, and knowledge and practice in LSS, as explained in the next subsections.

9.4.1 Contribution to theory and knowledge

In a doctoral thesis, it is essential to demonstrate a contribution to theory, as the theoretical contribution is most important in doctoral research (Easterby-Smith et al., 2012). The contribution to theory can be in different ways, including "confirmation of existing theories, extension of a theory into new areas, new conjunctions between previously separate theories or disciplines, generation of hypothesis, advances in methodology and so on" (Bititci and Ates, 2008, p.23). As pointed out in this research, LSS implementation is relatively recent, with limited published data regarding its deployment in developing countries and, hence, it is important to extend knowledge in this area. This research contributes to the advancement of the application of methodology within LSS research in Saudi Arabian organisations through the adoption of a mixed method approach.

This research has made an original contribution to knowledge by conducting a systematic literature review, survey and case studies to develop a body of knowledge on the status of LSS deployment. The research is one of the first systematic literature reviews to explore the most common themes within Lean Six Sigma. The systematic review allowed the researcher to develop a conceptual understanding of the key themes associated with LSS implementation and LSS characteristics such as CSFs, benefits, motivational factors, failure factors, challenges, tools and techniques (Albliwi et al., 2015). The systematic review also included the critical failure factors of LSS and discussed the top failure factors (Albliwi et al., 2014).

Very little research has been carried out relating to the status of LSS implementation in Saudi Arabian industry. Therefore, this research has contributed to establishing the current status of LSS in Saudi Arabian organisations, and has made a contribution to both theory and knowledge by assessing the current status of Lean Six Sigma in Saudi Arabian organisations and investigating LSS implementation characteristics (success factors, benefits, challenges) and comparing the results to the literature and to the situation in Western countries.

Another contribution to theory and the body of knowledge was through the systematic review of the available maturity models for business process excellence and LSS in particular. The review revealed inadequacies in the available practical maturity models and the absence of models to assess the current level of LSS deployment, especially for developing countries. Thus, the development of LSSMM in this research was an attempt to bridge the research gap, which is the absence of an appropriate Lean Six Sigma maturity model.

A further theoretical contribution has been provided through giving completed answers for the four research questions established at the beginning of this research and developing a better understanding of the areas less explored in the literature. It is also considered that a decent contribution has been made to management theories, as presented in Chapter 2 (section 2.9), which is outlined in the following subsection.

9.4.1.1 Theory of motivation

This study highlighted a lack of empirical studies to identify which types of motivation (intrinsic or extrinsic) are most instrumental for employees to be involved in Six Sigma projects and training in the Middle East (Walley, 2014). There is also a lack of studies investigating the influence of motivation on LSS deployment and the consequences of lack of financial rewards on LSS progress (Buch and Tolentino, 2006). Therefore, this study contributes to extending the theory of motivation into Lean Six Sigma implementation by investigating the employees' motivation towards LSS projects and training within the Saudi Arabian context and motivating factors for Saudi organisations to deploy LSS, as follows:

- The most applicable type of motivation to support LSS implementation;
- The extent of using extrinsic motivation to encourage LSS team members;
- The employees' motivation to become involved in LSS projects and LSS training;
- The most common motivating factors for Saudi organisations to deploy LSS.

The study has highlighted that the current status of employee motivation in the participating organisations is contrary to the theory of motivation proposed by Herzberg, (1959) and Herzberg et al., (2011), which states that financial recognition for employees is one of the main factors for employees' motivation to work. In contrast, the findings of this research support motivational theories which hold that employees are motivated through human recognition rather than financial reward; however, some of the LSS team members were more interested in the financial reward that comes from successful LSS projects. The findings of this study show that in Saudi organisations the relation between LSS and intrinsic motivation is more applicable, whereas extrinsic motivation was rarely found in the study, due to the absence of financial reward. The researcher argues that, although focusing on intrinsic motivation of employees across the firm is the way to sustain the benefits from LSS implementation and lead to higher organisational performance (Pamfilie et al., 2012), it should be supported by extrinsic motivation, to retain employees and increase their level of performance (Snee and Hoerl, 2003). In other words, both types of motivation are needed in the Saudi context. However, the author argues that there is a research gap in explaining the best combination between intrinsic and extrinsic motivation that is required to sustain LSS initiatives in Saudi organisations. In addition, it is important to explore the effect of each type of motivation on the LSS project's success (project outcomes), i.e. soft benefits and hard benefits. So if both types of motivation are combined, what are the project's outcomes: are they going to be soft benefits or hard benefits or both?

It was found that the participants had self-motivation to be involved in LSS training and be members of project teams, to learn more skills, as suggested in the literature (Buch and Tolentino, 2006). Participants stated that they agreed to be involved in LSS teams because they wanted to carry out projects and they believed in the power of LSS to build their knowledge (Snee and Hoerl, 2003), because they regarded LSS is a new field in the Saudi market, which will have a bright future in Saudi organisations. On the other hand, it was observed that some participants were disappointed by the lack of financial reward, which led some LSS team members to quit their work with the LSS team and to go back to their normal job that they used to do before they were involved in the LSS team. Other employees decided to find better job opportunities in other companies, where they could have better financial income and a better work environment. Therefore, employee retention was a challenge in some Saudi organisations, due to lack of financial reward. This finding supports the view of Snee and Hoerl, (2003) who argue that employees could be demotivated due to lack of tangible motivation such as financial rewards.

It can be concluded that the findings of this study support previous studies by Gitlow (1994, 2009) and Snee and Hoerl (2003) suggesting that management should understand the difference between intrinsic and extrinsic motivation and ensure a balance between the two types of motivation for LSS team members. This because each person needs a mix of the two types of motivation (Gitlow, 1994, 2009; Snee and Hoerl, 2003) and what motivates one individual might be a de-motivator for another individual (Harris, 2001).

The findings of this study support the X and Y theory for employee motivation proposed by McGregor (1960) (explained in section 2.9.1). According to McGregor, in order to manage people more effectively, managers should understand their employees' motivation to work, stating that X-type employees resist change and reward is the most common motivation for this type of employee. Accordingly, it is clear that some managers in the participating organisations had failed to understand their employees' motivation to work. If managers were aware that they had X-type employees, who resist change, and if managers knew that the best motivation would be rewarding those employees, then resistance to LSS deployment and the accompanying culture change would not happen in the participating organisations. On the other hand, according to McGregor, Y-type employees need a work environment and organisational culture that supports their desire and supports their creativity. If these needs are not met, there might be a high possibility that such LSS team members will find better job opportunities in other corporations where there is a work environment that meets their aspirations. This was clear in organisations B and D, which failed to retain their Six Sigma team members for more than three years (from 2005 to 2008). To conclude, lack of managers' understanding of their employees' motivation to work was a strong reason for the failure or slow progress of LSS in the participating organisations.

The final contribution to the theory of motivation in this study is related to organisational motivation (explained in section 2.9.1.1), which focuses on the motivation of organisations to deploy CI practices such as TQM, Six Sigma and others (Buch and Rivers, 2001; Buch and

Tolentino, 2006). The results of this study show different findings from those in the literature, where financial saving to the bottom-line is identified as the main motivation for organisations in Western countries. In this study it was found that financial saving was not the main priority for most of the organisations to deploy LSS, particularly in public sector organisations. Participants stated that quality, efficiency and customer satisfaction were the main priorities, while financial benefits would come later, due to quality improvement and waste reduction.

This leads to the conclusion that what motivates organisations to deploy LSS in the West may not necessarily be applicable in Middle Eastern countries. Each country has different culture and different government policies. For instance, organisations in Saudi Arabia do not pay taxes to run operations and people who live in Saudi Arabia and other Gulf countries do not pay taxes for living expenses, nor for public services, unlike those in Western countries (Taghawi-Nejad, 2015). This could be a likely explanation for the financial saving to the bottom-line not being considered as a top motivation for most of the organisations in Saudi Arabia.

9.4.1.2 Organisational learning theory

This study has highlighted the need for more empirical studies to increase the understanding of how learning practices can support and sustain CI practices in the Middle East (Al-Najem, 2014; Asfour, 2012) and what type of learning occurs in the implementation of CI initiatives such as LSS (Choo et al., 2007; Savolainen and Haikonen, 2007).

Hence, it was of importance to investigate many issues related to LSS and organisational learning theory within the Saudi Arabian context, including:

- The most applicable type of organisational learning to support LSS implementation;
- The possibility of using double-loop learning in LSS projects (Arumugam, 2015; Lagrosen et al., 2011; Roth et al., 1994);
- The most common learning practices, as suggested by many authors, e.g. Garvin (1993) and Sony and Naik (2012), and their influence on LSS implementation;
- Using the PDCA cycle with LSS projects as a learning method and a structure for sustaining learning (Savolainen and Haikonen, 2007; Roth et al., 1994).

The empirical study revealed the most commonly applied organisational learning type in the sample organisations to be single-loop learning. This finding supports the literature, where it was found that single-loop learning is more common for LSS implementation than double-loop learning (Knowles, 2011; Lagrosen et al., 2011; Savolainen and Haikonen, 2007). However, it is possible to use double-loop learning in LSS by encouraging employees to be open towards new ways of doing work. This can be through using more advanced statistical tools and techniques, such as DOE, FMEA and the Taguchi method, instead of using the same simple tools for all projects (Arumugam, 2015). The PDCA cycle can create opportunities for double-loop learning and is a very common method for learning in quality practices (Roth et al., 1994). However, this method was not considered as more than a cycle for continuous improvement of Lean projects, while in some cases it was a vehicle for project failure, due to lack of follow-up from BBs. Double-loop learning is also related to new product development (Anand et al., 2009), which can be through the adoption of DFSS methodology. However, there is a dearth of information in the literature to explain the relation of DFSS projects and double-loop learning.

In addition, the empirical study shows that only basic organisational learning practices were available in the sample organisations (mostly in private sector organisations). This includes sharing knowledge and experience of LSS deployment via databases, knowledge networks, regular meetings, communication boards, daily e-mails, presentations, open discussions and reports. However, little evidence of learning from failure, mistakes and incidents was available. Learning from the joint venture organisation and parent organisation remained basic. Learning organisation practices such as continuous learning, practice of learning in daily life, supportive learning environment, and creating a culture of learning had not yet been achieved to the degree needed for a complete implementation of LSS in the sample organisations (Lagrosen et al., 2011). This was due to the problem that the prevailing attitude towards failure was to take it personally, with the result that individuals were less inclined to discuss their failures. Moreover, in public sector organisations it was not acceptable to criticise others (particularly managers) or to point out their weaknesses. The culture also was an obstacle for organisational learning. There was, as yet, no general culture of sharing mistakes and limitations. Therefore, it can be concluded that the organisational culture did not support organisational learning and also that there was a lack of communication between departments and individuals in some organisations. However, in order to achieve the learning organisation level, it seems that organisations in Saudi Arabia need more support from top management, if learning is to become part of the culture.

This study has contributed to establishing empirical research to link LSS to organisational learning theory. Thus the study contributes to theory in the area of operations management and extending organisational learning theory to LSS implementation. Previous studies have presented empirical evidence for the positive relationship between Lean/Six Sigma and organisational learning (Arumugam et al., 2013; Hines et al., 2004; Lagrosen et al., 2011; Savolainen and Haikonen, 2007; Sony and Naik, 2012; Watson, 2001), whereas this study has extended the theory of organisational learning to LSS implementation and maturity assessment in developing countries. In doing this, the study has contributed to validating the high positive impact of organisational learning theory on LSS implementation and maturity assessment. Organisational learning practices were involved in the maturity model to help organisations to achieve a high level of LSS maturity and to remain successful in the future (Pande et al., 2000).

9.4.2 Contribution to practice

It is very important for applied research that the conclusions drawn from the research can help to make changes to practice. As management research is considered to be applied research, a contribution to practice is required in judging the research quality, especially for studies that aim to build theory or to connect theory with practice (Bititci and Ates, 2008). This study is based on a comprehensive literature review which gives an opportunity for LSS researchers and academics to understand in depth some common themes within LSS (Albliwi et al., 2015). Before starting the LSS implementation process, it is important for practitioners to be aware of the benefits, limitations and impeding factors of LSS. Hence, this research could provide valuable insights to practitioners, especially in developing countries. The key findings of the systematic review can be used by senior managers to help them to understand the key implementation elements before they embark upon the LSS journey. Moreover, the findings from the research can also act as a set of guidelines (in terms of CSFs, barriers, benefits, motivation) for the introduction development and implementation of LSS. This study could thus prove valuable to researchers, practitioners and LSS consultants who are interested in the application of LSS in the Saudi Arabian context. The information gathered and interpreted provides useful insights on the understanding and implementation of LSS in diverse Saudi Arabian organisations by comparing the information found in the literature to the reality of Saudi Arabian organisations today. This has been achieved by translating the key success factors, benefits, and challenges of LSS implementation, as experienced in Western countries, to be more relevant and relatable to the challenges faced in Saudi Arabia, especially in terms of organisational learning, organisational culture and the resistance to change. The systematic review of the critical failure factors is valuable for CEOs and managers, who should pay attention to the critical success factors and should be aware of the most common failure factors that lead other organisations in the same industry to fail in their LSS projects (Albliwi et al., 2014).

The empirical research in this study is one of few studies to determine the current status of CI practice in developing countries. This research presents the issues and key findings from Saudi Arabian organisations in regard to LSS, which contribute to the future development of Saudi Arabian industries through presenting the best practices and identifying the negative ones. This provides critical information to managers in Saudi Arabia to develop a strategic plan for successful LSS implementation.

The development of the LSSMM has been an attempt to bridge the research gap, which is the absence of a Lean Six Sigma maturity model. Without using a maturity model, organisations deploying LSS cannot assess their current maturity level and hence keep carrying out the same simple practices for many years, while other organisations may fail to sustain LSS. Therefore, this research contributes to both theory and practice by developing five levels of maturity that are necessary for sustained success and identifying areas for improvement and growth and making better decisions.

9.4.3 Research limitations

This study, as with other previous studies, has limitations.

1- One limitation is in the systematic review (Chapter 2), where some studies were excluded from the analysis. This was due to the inclusion and exclusion criteria that were developed by the researcher, to include only top-ranking journals (according to ABS, 2013 and Harzing, 2013) and specialist journals in the field.

2- Another limitation is narrowing the research to Saudi Arabian organisations only – however, this country has a greater number of organisations than other countries in the region, and therefore that has enabled a greater depth of knowledge to be applied to this study. Similar studies will therefore need to be conducted in other Middle Eastern countries in the future.

3- This research was constrained to Saudi Arabian organisations; therefore, if these insights were to be used generically in other developing countries, validation of the conclusions presented in relation to other countries should be conducted, to ensure they are still well-founded in a different context.

4- The main limitations of the research design are those commonly associated with the qualitative approach and semi-structured interviews: that is, the potential for researcher bias and the possible impact on reliability and validity of instrument quality. However, these limitations were taken into account during the research design process, with data triangulation, methodological triangulation and theory triangulation all being adopted to reduce any bias.

5- The primary limitation of the survey is that data have been collected from an online survey, and therefore no deeper insights could have been captured from the survey. This limitation has been rectified to some extent by executing semi-structured interviews in selected organisations within Saudi Arabia in the third phase of the research.

6- The primary limitation of the case study phase could be the number of the cases being limited to five organisations, which is regarded as being too few for generalisation. However, this was due to the time constraints of three months imposed by the researcher’s sponsor (The Saudi Cultural Bureau) to collect all the required data, as well as the limited financial support.

7- Another limitation is the restriction of the case study sample to large organisations located in Saudi Arabia. However, the research is unique in conducting an in-depth investigation of Lean Six Sigma in this country.

8- The maturity model was customised for Saudi Arabian organisations, based on the interview results and the systematic review of the available models in the literature (published and unpublished models). Therefore, the model could be not applicable for Western countries, which makes the development of customised models for other countries highly recommended. The researcher argues that the model might be useful for other developing countries that have LSS deployment characteristics similar to those in Saudi organisations. This point will be addressed in future research.

9- Due to limitations in time and financial resources, the maturity model validity was established through only 14 people working in Saudi organisations. They were asked to give their feedback on the model and if the model would be of benefit to Saudi organisations. This point will be addressed in future research.

10- Each of the maturity activities or characteristics and categories were given equal importance when calculating LSS maturity scores. Therefore, it is strongly suggested that further empirical studies be conducted to determine a rank order of importance for the activities/ characteristics and categories.

9.5 Research conclusion

This study has shown that there is a noticeable increase in the popularity of LSS and level of LSS deployment in the industrial world, especially in large organisations in Western countries such as the USA, the UK and the Netherlands, and in some SMEs in developing countries such as India. In contrast, the results of the empirical study show that there are still diverse areas of improvement to be addressed before Saudi organisations can obtain all the expected benefits yielded by LSS implementation. As a starting point, more focus is needed on resolving the issues regarding training, customers' needs, project selection and execution, investment, calculating the financial benefits, cultural changes, and effective leadership. Furthermore, improved communication between business units, employees and management, as well as the integration of the Six Sigma team into all departments, would aid the understanding and implementation of LSS initiatives. Many issues have emerged related to lack of reward and lack of motivation, which have resulted in losing experts and other LSS team members. In addition, there was a lack of maturity assessment, due to the absence of a LSS maturity model. Therefore, the maturity model developed in this study has contributed to assess the current level of maturity in the case organisations, and can contribute to indicating the level of LSS maturity in other organisations in the future. It will be useful for organisations to assess their current level of maturity and plan the future direction towards LSS sustainability. In addition, many gaps in the current LSS literature have been identified, such as the absence of a framework for sustainability of LSS and a lack of research into the relation between LSS and organisational learning. Therefore, a future research agenda for LSS has also been developed in this research.

9.5.1 Agenda for future research

This agenda is an important research output to help other researchers in the field to direct their future research in the following areas:

1- LSS and its impact on organisational performance (financial performance, operational performance, tactical performance).
2- Expansion of the current LSS toolkit, especially in different disciplines such as healthcare, financial services, higher education, and manufacturing.

3- Determining the LSS facilitator role and skills and developing a guide for choosing an appropriate facilitator from inside or outside the organisation.
4- Case studies to examine the practical value of the integrated framework of LSS in different sectors.
5- Certification systems, as there are currently no specific requirements for certification, as well as the lack of an authority for the certification process.
6- LSS and its link to innovation as a key driver for organisations to survive, grow and sustain competitiveness.
7- LSS for enhancing supply chain performance and how long-term relationships with suppliers can improve productivity, quality and customer satisfaction.
8- LSS and Environmental Management Systems (Green LSS), to explore the relation between LSS and the environment. This will be helpful for environmental professionals, to guide them on how to connect their work with LSS activities to generate better environmental and operational results.
9- LSS for public sector organisations such as healthcare, education, councils and police forces.
10- LSS for High Value and Low Volume Environments, in which it has not been fully understood and correctly applied, such as the deployment of LSS in the aerospace manufacturing industry.
11- LSS Readiness Index Model to assess the readiness of an SME to embark on a LSS journey.
12- Leadership and its impact on successful deployment of LSS.

9.5.2 Future research direction

Future research is needed to address the limitations identified in this research and allow the research findings to be generalised. A part of that includes the following points:

1- To extend the research scope to include more organisations in Saudi Arabia, to understand and assess LSS characteristics across different industries. This could be a comparative study between large organisations and SMEs or public and private sector, manufacturing and service sector, for example.
2- The maturity model was validated by 14 people only, which may be a point of weakness and criticism of the model. Therefore, future research will be directed to

targeting more people in the field of LSS in Saudi Arabia and asking them for their feedback for further improvement to the model.

3- Using the developed LSSMM to assess the current level of LSS deployment in other organisations, including large organisations and SMEs. This will increase the validity of the model and help more organisations to assess their level of maturity.
4- The researcher is looking to extend this study in future research to include other Gulf countries, such as the UAE, Kuwait, Qatar and Oman, to assess the current level of LSS deployment and compare the findings with Saudi Arabian organisations and Western countries. This will contribute to sharing knowledge and best practices across different countries.
5- Further research will be conducted to explore the critical differences in organisational performance of LSS and non-LSS organisations.
6- It was observed that most of the participating organisations have very low scores in the tools and techniques category, i.e. 1 or 2 out of 5, indicating that they are not using advanced statistical tools and techniques. However, there is a shortage of research to explain the exact tools and techniques that should go in each maturity level. Therefore, it is essential to extend this research in the future by empirically developing a maturity model for tools and techniques that includes all LSS tools and techniques. So in order to get scores of 5 in tools and techniques, organisations need to use all the tools and techniques that appear in the literature, as suggested by world-class scholars.

9.5.3 Critical reflection on the research journey

Conducting this research during the past four years has allowed the author, to some extent, to understand the current level of LSS deployment in Saudi Arabia and in other countries. The author’s observation is that it is impossible to say that there is an optimal level of LSS deployment in one country. This is due to many factors which can affect the level of LSS deployment, including the availability of resources, motivational factors, top management commitment and support, level of training, individual’s mindsets and cultural aspects.

Another observation in this study is that, despite the country’s level of evolution or LSS deployment, resistance to change was found to be a major challenge for LSS implementation across different countries. This fact was highlighted in the literature and also reported by practitioners and academics in conferences that the author attended during her PhD journey.

Resistance to change is in human nature, where people have a fear of change because of the uncertainty involved in change. This led some people to use the same tools and techniques for all projects, even if the benefits were few and basic.

The findings from the empirical study suggest that the Saudi Arabian organisations are lagging behind the USA organisations in terms of LSS deployment level. This may be due to the lack of experienced personnel in Saudi organisations during the past years. Most of the Saudi organisations in this study had no formal programme for LSS deployment, which makes the deployment level dependent on the effort of the available people, and hence leads to lack of sustainability. In addition, there is a big difference in the level of people's awareness and organisations' awareness of LSS between Saudi Arabia and Western countries. This is because LSS has only recently been introduced to Saudi organisations i.e. for around six years, whereas it has been deployed in Western countries for more than two decades. Another reason is the absence of professional bodies for quality and CI in Saudi Arabia during the past years, whereas Western countries have had these societies for many decades, such as the American Society for Quality (ASQ), which was established in 1946 and the British Quality Foundation (BQF), which was established in 1993. These associations have major roles in disseminating knowledge and awareness of CI initiatives through certification, training, publications, conferences, and other services. However, in 2011, the Minister of Commerce and Industry announced the establishment of the Saudi Society for Quality (SSQ), with the aims of improving and developing the quality of services, products, and information and dissemination of the quality culture and its concepts, and to apply those concepts in the public and private sectors, and to contribute to the field of quality.

The empirical study shows that LSS was found to be useful for Saudi organisations, to some extent, although there are many limitations and challenges. This was clear from the simple benefits generated through LSS projects. The benefits of LSS to Saudi organisations were at departmental level but not organisation-wide. It was found that public sector organisations are lagging behind private sector organisations in terms of LSS deployment. Private organisations obtain many benefits from LSS, due to collaboration with world-class organisations through joint ventures. Nevertheless, the deployment in both sectors remains in the early stages.

The author would argue that, with the current situation, and with the clear lack of training, infrastructure, number of completed projects, and basic tools and techniques, LSS will not be able to be sustained in Saudi organisations for more than 10 years unless major changes are applied in the organisational culture to ensure the successful deployment of any CI initiative within the next 5 to 10 years. However, due to the existing world economic situation, the Saudi government has realised the importance of reducing expenses across the country and not relying on oil as the main source of revenue. The Saudi government has recently, in April 2016, announced the new economic plan of the country that is called 'Vision 2030', which calls for an increase in the sources of income, creating job opportunities and bringing about a real change in the kingdom. With this vision, the author is expecting that LSS will have a bright future in Saudi organisations in all sectors. The author personally believes that organisations will start to focus more on cutting cost through increasing efficiency and generating hard benefits to the bottom-line. This gives LSS a great opportunity to become more recognised in Saudi organisations, especially with the massive increase in a well-educated younger population. At this point, the author believes that quality and CI professional bodies will have an important role in disseminating the knowledge of LSS and other quality management tools in order to increase the awareness of CI across the country.

9.5.4 Personal reflection

Although conducting a PhD research study was the hardest task in the author's life, it was also a great opportunity to learn and improve her knowledge in various fields. Four years ago the author was struggling to understand the term 'Lean Six Sigma' and to date the author has published four journal papers and four conference papers on LSS. Undertaking a PhD research study has added a lot to the author's knowledge, experience and personality. The author learned how to carry out good research and to become confident to talk about research and the author has also become a strong person who can survive and fight for the future. The opportunity that the author had in Strathclyde University to teach some LSS classes for MSc students in 2012 and 2013 was a great chance to share her passion in the classroom.

Meeting scholars and pioneers in the field of operations management during conferences, courses and workshops was an opportunity to exchange knowledge, get valuable comments to improve her research and to present her country. As an academic and a lecturer at King Abdulaziz University, with lack of practical experience in industry, it was highly valuable to conduct empirical research and visit five organisations in Saudi Arabia. Visiting organisations to collect data was highly interesting and allowed the author to see the real industry that the author previously knew only from journal papers and to make contact with people who will help her in future work.

However, the past years were full of challenges and tears. Being away from home, warm family and friends for seven years was very tough. Moreover, as English is not the author's first language, it was hard for her sometimes to understand the academic language especially that in the top journals. At the beginning, the author was struggling to transfer her ideas and shape them in an academic way that makes sense to the reader as native English speakers do. But in the end she did it!

At this point, the author can say that she is extremely proud of her achievements and she really would like to do more LSS research within the Saudi Arabian context in the near future, when she goes back to her work as an assistant professor at King Abdulaziz University. The author is keen to transfer what she has learned from Western countries during the past years to her own country.

References

Abdelhadi, A. and Shakoor, M. (2014), 'Studying the efficiency of inpatient and outpatient pharmacies using lean manufacturing', *Leadership in Health Services*, Vol. 23 No. 3, pp. 255–267.

Abdelhadi, A.N. (2014), 'Application of Toyota's Production System to Reduce Traffic Accidents in Abha's Region - Case Study', *International Conference on Industrial Engineering and Operations Management,* Bali, Indonesia.

Aboelmaged, M.G. (2011), 'Reconstructing Six Sigma barriers in manufacturing and service organizations: The effects of organizational parameters', *International Journal of Quality & Reliability Management*, Vol. 28 No. 5, pp. 519–541.

Aboelmaged, M.G. (2010), 'Six Sigma quality: a structured review and implications for future research', *International Journal of Quality & Reliability Management*, Vol. 27 No. 3, pp. 268–317.

'ABS'. (2013), Available at: http://www.associationofbusinessschools.org/content/abs-academic-journal-quality-guide/ (accessed 16 January 2013).

Agin, E. and Gibson, T. (2010), 'Developing an innovative culture', *American Society for Training and Development*, USA, pp. 52–55.

Ahmed, S., Manaf, N.H.A. and Islam, R. (2013), 'Effects of Lean Six Sigma application in healthcare services: a literature review', *Reviews on Environmental Health*, Vol. 28 No. 4, pp. 189–194.

Akbulut-Bailey, A.Y., Motwani, J. and Smedley, E.M. (2012), 'When Lean and Six Sigma converge: a case study of a successful implementation of Lean Six Sigma at an aerospace company', *International Journal of Technology Management*, Vol. 75 No. 1/2/3, pp. 18–32.

Akkerhuis, T.S., Spanjaard, C.M., Nuijten, S.E., Berendes, O.G. and Does, R.J.M.M. (2015), 'Quality Quandaries: Realizing Strategic Focal Points at a Business School', *Quality Engineering*, Vol. 27 No. 2, pp. 267–273.

Al-Ahmadi, H. (2011), 'Challenges facing women leaders in Saudi Arabia', *Human Resource Development International*, Vol. 4 No. 2, pp. 149–166.

Al-Darrab, I.A., Gulzar, W.A. and Ali, K.S. (2013), 'Status of implementation of safety, quality and environmental management systems in Saudi Arabian industries', *Total Quality Management & Business Excellence*, article, , Vol. 24 No. 3–4, pp. 336–354.

Al-Mashari, M. (2001), 'Process Orientation through Enterprise Resource Planning (ERP): A Review of Critical Issues', *Knowledge and Process Management*, Vol. 8 No. 3, pp. 175–185.

Al-Najem, M. (2014), *Investigating the factors affecting readiness for lean system adoption within Kuwaiti small and medium-sized manufacturing industries*, PhD Thesis, University of Portsmouth.

Al-Najem, M., Dhakal, H.N., Labib, A. and Bennett, N. (2013), 'Lean readiness level within Kuwaiti manufacturing industries', *International Journal of Lean Six Sigma*, Vol. 4 No. 3, pp. 280–320.

Al-Qahtani, S.S. and Al-Methheb, M.M. (1999), 'Implementation of Total Quality Management in some Saudi Public Sector Organizations', *JKA: Econ & Adm*, Vol. 13 No. 2, pp. 23–38.

Al-Sadat, M.A. and Robertson, K.E. (2007), *Using Lean Six Sigma to Increase Productivity in Generating the Digital Terrain Model (DTM)*, Aramco, unpublished case study.

Al-Shafei, A.I., Abdulrahman, K., Al-Qumaizi, K.I. and El-Mardi, A.S. (2015), 'Developing a generic model for total quality management in higher education in Saudi Arabia', *Medical Teacher*, Vol. 37 No. 1, pp. S1–S4.

Al-Sulimani, T. (1995), 'Total Quality Management in Saudi Manufacturing Industry- A survey based implementation plan’, *The Fourth Saudi Engineering Conference*, King Abdulaziz University, Jeddah.

Al-Beraidi, A. and Rickards, T. (2003), ‘Creative team climate in an international accounting office: an exploratory study in Saudi Arabia’, *Managerial Auditing Journal*, Vol. 18 No. 1, pp. 7–18.

Al-Maghrabi, T. and Dennis, C. (2011), ‘What drives consumers’ continuance intention to e-shopping?: Conceptual framework and managerial implications in the case of Saudi Arabia’, *International Journal of Retail & Distribution Management*, Vol. 39 No. 12, pp. 899–926.

Alameen, L., Male, T. and Palaiologou, I. (2015), ‘Exploring pedagogical leadership in early years education in Saudi Arabia’, *School Leadership & Management: Formerly School Organisation*, Vol. 35 No. 2, pp. 121–139.

AlAmin, M. and Karim, M.A. (2013), ‘A time-based quantitative approach for selecting lean strategies for manufacturing organisations’, *International Journal of Production Research*, Vol. 51 No. 4, pp. 1146–1167.

Albassam, B.A. (2015), ‘Does Saudi Arabia’s economy benefit from foreign investments?’, *Benchmarking: An International Journal*, Vol. 22 No. 7, pp. 1214–1228.

Albayoudh, K.A. (2003), *Assessment of total quality management in the Saudi construction industry organisations*, PhD Thesis, Loughborough University.

Albliwi, S.A., Antony, J. and Lim, S.A. halim. (2015), ‘A systematic review of Lean Six Sigma for the manufacturing industry’, *Business Process Management Journal*, Vol. 21 No. 3, pp. 665–691.

Albliwi, S., Antony, J., Lim, S. and Wiele, A. van der. (2014), ‘Critical failure factors of Lean Six Sigma: a systematic literature review’, *International Journal of Quality & Reliability Management*, Vol. 31 No. 9, pp. 1012–1030.

Algassem, F., Yang, Q. and Au, J. (2014), ‘Application of Lean Six Sigma Principles to Food Distribution SMEs’, *American Academic & Scholarly Research Journal*, Vol. 6 No. 4, pp. 1162–1170.

Alharti, A.A., Sharaf, M.A. and Aziz, T. (2014), ‘An Integrated Approach Lean Six Sigma and Risk Management in Entertainment and Media Industry’, *the International Conference on Industrial Engine*, p. 2917.

Almuharib, T.M. (2014), *Service Quality Improvement Through Lean Management at King Khalid International Airport in Saudi Arabia*, PhD Thesis, Plymouth University.

Alrabeah, A.H., Ogden, S.M., Edgar, D.A. and Fryer, K.J. (2015), ‘TQM in the Saudi Health Care System: A National Cultural Perspective’, *World Review of Business Research*, Vol. 5 No. 2, pp. 120–136.

Alrubaish, A. (2010), ‘On the Contribution of Student Experience Survey Regarding Quality Management in Higher Education: An Institutional Study in Saudi Arabia’, *Journal of Service Science and Management*, Vol. 3 No. 4, pp. 464–469.

Alruwaili, J. (2013), ‘Total Quality Management in Education Directorates in Saudi Arabia: Contrasting Provincial Case Studies’, *Public policy and administration research*, Vol. 3 No. 6, pp. 26–34.

Alsaleh, N.A. (2007), ‘Application of quality tools by the Saudi food industry’, *The TQM Magazine*, Vol. 19 No. 2, pp. 150–151.

Alsmadi, M. and Khan, Z. (2010), ‘Lean sigma: the new wave of business excellence, literature review and a framework’, *Second International Conference on Engineering Systems Management and its Applications (ICESMA), March 30 – April 1, pp.1-8.*

Alsmadi, M., Lehany, B. and Khan, Z. (2012), ‘Implementing Six Sigma in Saudi Arabia: An empirical study on the Fortune 100 firms’, *Total Quality Management & Business Excellence*, Vol. 23 No. 3, pp. 263 – 276.

Amminudin, K.A., Enezi, T.S., Jubran, M.A., Hajji, A.T., Enizi, A.S. and Bedoukhi, Z.F. (2011), 'Gas plant improves C3 recovery with Lean Six Sigma approach', *Oil and Gas Journal*, Vol. 109 No. 19, pp. 102–109.

Anand, G., Ward, P.T. and Tatikonda, M. V. (2010), 'Role of explicit and tacit knowledge in Six Sigma projects: An empirical examination of differential project success', *Journal of Operations Management*, Vol. 28 No. 4, pp. 303–315.

Anand, G., Ward, P.T., Tatikonda, M. V and Schilling, D.A. (2009), 'Dynamic capabilities through continuous improvement infrastructure', *Journal of Operations Management*, JOUR, , Vol. 27 No. 6, pp. 444–461.

Anderson, N.C. and Kovach, J. V. (2014), 'Reducing Welding Defects in Turnaround Projects: A Lean Six Sigma Case Study', *Quality Engineering*, Vol. 26 No. 2, pp. 168–181.

Andersson, R., Eriksson, H. and Torstensson, H. (2006), 'Similarities and differences between TQM, six sigma and lean', *The TQM Magazine*, Vol. 18 No. 3, pp. 282–296.

Andrade, M.S. (2011), 'Managing Change-Engaging Faculty in Assessment Opportunities', *Innovative Higher Education*, Vol. 36 No. 4, pp. 217–233.

Antony, J. (2004), 'Six sigma in the UK service organisations: results from a pilot survey', *Managerial Auditing Journal*, Vol. 19 No. 4, pp. 1006–1013.

Antony, J. (2006), 'Six sigma for service processes', *Business Process Management Journal*, Vol. 12 No. 2, pp. 234–248.

Antony, J. (2007), 'Is six sigma a management fad or fact?', *Assembly Automation*, Vol. 27 No. 1, pp. 17–19.

Antony, J. (2008), 'Reflective practice: can Six Sigma be effectively implemented in SMEs?', *International Journal of Productivity and Performance Management*, Vol. 57 No. 5, pp. 420–423.

Antony, J. (2011), 'Six Sigma vs Lean', *International Journal of Productivity and Performance Management*, Vol. 60 No. 2, pp. 185–190.

Antony, J. (2012), 'A SWOT analysis on Six Sigma: some perspectives from leading academics and practitioners', *International Journal of Productivity and Performance Management*, Vol. 61 No. 6, pp. 691–698.

Antony, J. (2013), 'What does the future hold for quality professionals in organisations of the twenty-first century?', *The TQM Journal*, Vol. 25 No. 6, pp. 677–685.

Antony, J. (2015), 'Challenges in the deployment of LSS in the higher education sector: Viewpoints from leading academics and practitioners', *International Journal of Productivity and Performance Management*, Vol. 64 No. 6, pp. 893–899.

Antony, J., Antony, F.J., Kumar, M. and Cho, B.R. (2007), 'Six sigma in service organisations: Benefits, challenges and difficulties, common myths, empirical observations and success factors', *International Journal of Quality & Reliability Management*, Vol. 24 No. 3, pp. 294–311.

Antony, J. and Banuelas, R. (2002), 'Key ingredients for the effective implementation of Six Sigma program', *Measuring Business Excellence*, Vol. 6 No. 4, pp. 20–27.

Antony, J., Bhuller, A.S., Kumar, M., Mendibil, K. and Montgomery, D.C. (2012a), 'Application of Six Sigma DMAIC methodology in a transactional environment', *International Journal of Quality & Reliability Management*, Vol. 29 No. 1, pp. 31 – 53.

Antony, J. and Desai, D.A. (2009), 'Assessing the status of six sigma implementation in the Indian industry: Results from an exploratory empirical study', *Management Research News*, Vol. 32 No. 5, pp. 413–423.

Antony, J., Downey-Ennis, K., Antony, F. and Seow, C. (2007), 'Can Six Sigma be the "cure" for our "ailing" NHS?', *Leadership in Health Services*, Vol. 20 No. 4, pp. 242–253.

Antony, J., Escamilla, J.L. and Caine, P. (2003), ‘Lean Sigma’, *Manufacturing Engineer*, Vol. 82 No. 2, pp. 40–42.

Antony, J. and Fergusson, C. (2004), ‘Six Sigma in the software industry: results from a pilot study’, *Managerial Auditing Journal*, Vol. 19 No. 8, pp. 1025–1032.

Antony, J., Krishan, N., Cullen, D. and Kumar, M. (2012b), ‘Lean Six Sigma for higher education institutions (HEIs): Challenges, barriers, success factors, tools/techniques’, *International Journal of Productivity and Performance Management*, Vol. 61 No. 8, pp. 940 – 948.

Antony, J. and Kumar, M. (2012), ‘Lean and six sigma methodologies in NHS Scotland: An empirical study and directions for future research’, *Quality Innovation Prosperity*, Vol. 16 No. 2, pp. 19–34.

Antony, J., Kumar, M. and Labib, A. (2008), ‘Gearing Six Sigma into UK manufacturing SMEs: results from a pilot study’, *Journal of the Operational Research Society*, Vol. 59 No. 4, pp. 482–493.

Antony, J., Kumar, M. and Madu, C.N. (2005), ‘Six sigma in small-and medium-sized UK manufacturing enterprises: Some empirical observations’, *International Journal of Quality & Reliability Management*, Vol. 22 No. 8, pp. 860 – 874.

Antony, J., Setijono, D. and Dahlgaard, J.J. (2014), ‘Lean Six Sigma and Innovation – an exploratory study among UK organisations’, *Total Quality Management & Business Excellence*, Vol. 27 No. 1–2, pp. 124–140.

Argyris, C. (1982), ‘Organizational learning and management information systems’, *ACM SIGMIS Database*, Vol. 13 No. 2–3, pp. 3–11.

Argyris, C. and Schon, D. (1978), *Organizational Learning: A Theory of Action Perspective*, Addison-Wesley, Reading, MA.

Arumugam, S. (2015), *Synthesis and characterization of novel organic semiconducting materials for organic field effect transistors (OFETs) and photovoltaics (OPVs)*, PhD Thesis, University of Strathclyde.

Arumugam, V., Antony, J. and Douglas, A. (2012), ‘Observation: a Lean tool for improving the effectiveness of Lean Six Sigma’, *The TQM Journal*, Vol. 24 No. 3, pp. 275–287.

Arumugam, V., Antony, J. and Kumar, M. (2013), ‘Linking learning and knowledge creation to project success in Six Sigma projects: An empirical investigation’, *International Journal of Production Economics*, Vol. 141 No. 1, pp. 388–402.

Asfour, B. (2012), ‘Application of Lean Six Sigma to Optimize Admission Waiting Time at AL-Mowasah Hospital’, Master Thesis, Middle East University.

ASQ. (2009), ‘Lean Six Sigma Hospital Study Advisory Committee’, *Quality Progress*, Vol. 42 No. 8, pp. 44–50.

Assarlind, M., Gremyr, I. and Backman, K. (2013), ‘Multi-faceted views on a Lean Six Sigma application’, *International Journal of Quality & Reliability Management*, Vol. 30 No. 4, pp. 387–402.

Assarlind, M., Gremyr, I. and Bäckman, K. (2012), ‘Multi-faceted views on a Lean Six Sigma application’, *International Journal of Quality & Reliability Management*, Vol. 29 No. 1, pp. 21–30.

Ateekh-ur-Rehman, L.U.R. (2012), ‘Safety Management in a Manufacturing Company: Six Sigma Approach’, *Engineering*, Vol. 4 No. 7, pp. 400–407.

Bakar, F.A.A., Subari, K. and Daril, M.A.M. (2015), ‘Critical success factors of Lean Six Sigma deployment: a current review’, *International Journal of Lean Six Sigma*,Vol. 6 No. 4, pp. 339–348.

Ballard, G. and Howell, G.A. (2003), ‘Lean project management BT - Re-valuing Construction’, *Building Research and Information*, Vol. 31 No. 2, pp. 119–133.

Bamber, L. and Dale, B.G. (2000), ‘Lean production: A study of application in a traditional manufacturing environment', *Production Planning & Control: The Management of Operations*, Vol. 11 No. 3, pp. 291–298.

Banawi, A. and Bilec, M. (2014), 'Applying Lean, Green, and Six-Sigma Framework to Improve Exterior Construction Process in Saudi Arabia', *Journal of Construction Engineering and Project Management*, Vol. 4 No. 2, pp. 12–22.

Banuelas, R., Antony, J. and Brace, M. (2005), 'An application of Six Sigma to Reduce waste', *Quality and Reliability Engineering International*, Vol. 21 No. 6, pp. 553–570.

Banuelas, R., Tennant, C., Tuersley, I. and Tang, S. (2006), 'Selection of six sigma projects in the UK', *The TQM Magazine*, Vol. 18 No. 5, pp. 514–527.

Barney, M. (2002), 'Motorola's Second Generation', *Six Sigma Forum Magazine*, Vol. 1 No. 3, pp. 13–16.

Barratt, M., Choi, T.Y. and Li, M. (2011), 'Qualitative case studies in operations management: trends, research outcomes, and future research implications', *Journal of Operations Management*, Vol. 29 No.4, pp. 329–342.

Belassi, W. and Tukel, O.I. (1996), 'A new framework for determining critical success/failure factors in Projects', *International Journal of Project Management*, Vol. 14 No. 3, pp. 141–151.

Bendell, T. (2005), 'Structuring business process improvement methodologies', *Total Quality Management & Business Excellence*, Vol. 16 No. 8–9, pp. 969–978.

Bendell, T. (2006), 'A review and comparison of six sigma and the lean organisations', *The TQM Magazine*, Vol. 18 No. 3, pp. 255–262.

Bergman, B. and Klefsjo, B. (2010), *Quality from Customer Needs to Customer Satisfaction*, Lund, Studentlitteratur, 3rd ed.

Bessant, J. and Caffyn, S. (1997), 'High – involvement innovation through continuous improvement', *International Journal of Technology Management*, Vol. 14 No. 1, pp. 14–22.

Bessant, J., Caffyn, S. and Gallagher, M. (2001), 'An evolutionary model of continuous improvement behaviour', *Technovation*, Vol. 21 No. 2, pp. 67–77.

Bessant, J. and Francis, D. (1999), 'Developing strategic continuous improvement capability', *International Journal of Operations & Production Management*, Vol. 19 No. 11, pp. 1106–1119.

Bhanumurthy, M. V. (2012), 'Profitability through lean Six Sigma: Save energy-Save environment', *AIChE Annual Meeting, Conference Proceedings*, Pittsburgh.

Bhasin, S. (2011), 'Performance of organisations treating lean as an ideology', *Business Process Management Journal*, Vol. 17 No. 6, pp. 986–1011.

Bhasin, S. (2012a), 'An appropriate change strategy for lean success', *Management Decision*, Vol. 50 No. 3, pp. 439–458.

Bhasin, S. (2012b), 'Prominent obstacles to lean', *International Journal of Productivity and Performance Management*, Vol. 61 No. 4, pp. 403–425.

Bhasin, S. and Burcher, P. (2006), 'Lean viewed as a philosophy', *Journal of Manufacturing Technology Management*, Vol. 17 No. 1, pp. 56–72.

Bhaskar, R.A. (1989), *Reclaiming Reality: A Critical Introduction to Contemporary Philosophy*, Verso, London.

Bhat, S., Gijo, E.V. and Jnanesh, N.A. (2014), 'Application of Lean Six Sigma methodology in the registration process of a hospital', *International Journal of Productivity and Performance Management*, Vol. 63 No. 5, pp. 613–643.

Bhuiyan, N., Baghel, A. and Wilson, J. (2006), 'A sustainable continuous improvement methodology at an aerospace company', *International Journal of Productivity and Performance Management*, Vol. 55 No. 8, pp. 671–687.

Bisgaard, S. and Does, R.J.M.M. (2009), 'Quality Quandaries: Health CareQuality—

Reducing the Lengthof Stay at a Hospital', *Quality Engineering*, Vol. 21 No. 1, pp. 117–131.
Bititci, U. and Ates, A. (2008), 'Fundamental concepts in management research and ensuring research quality: focusing on case study method', *European Academy of Management Annual Conference*, Ljubljana.
Bjerke, B. and Al‐Meer, A. (1993), 'Culture′s Consequences: Management in Saudi Arabia', *Leadership & Organization Development Journal*, Vol. 14 No. 2, pp. 30–35.
Black, K. and Revere, L. (2006), 'Six Sigma arises from the ashes of TQM with a twist', *International Journal of Health Care Quality Assurance*, Vol. 19 No. 3, pp. 259–266.
Booth, A., Papaioannou, D. and Sutton, A. (2012), *Systematic Approaches to a Successful Literature Review*, SAGA, London, UK.
Boughzala, I. and de Vreede, G.-J. (2012), 'A Collaboration Maturity Model: Development and Exploratory Application', *45th Hawaii International Conference on System Sciences*. Maui, HI.
Brady, J.E. and Allen, T.T. (2006), 'Six Sigma literature: a review and agenda for future research', *Quality and Reliability Engineering International*, Vol. 29 No. 1, pp. 335–367.
Brereton, P., Kitchenham, B., Budgen, D. and Li, Z. (2008), 'Using a protocol template for case study planning', *12th International Conference on Evaluation and Assessment in Software Engineering*, University of Bari, Italy.
Breyfogle, F.W.I. (2003), *Implementing Six Sigma: Smarter Solutions Using Statistical Methods*, John Wiley & Sons, New York, USA, 2nd ed.
Breyfogle, F.W.I. (2008), 'Beyond troubleshooting', *ASQ Six Sigma Forum Magazine*, Vol. 8 No. 1, pp. 27–31.
Breyfogle, F.W.I., Cupello, J.M. and Meadows, B. (2000), *Managing Six Sigma: A Practical Guide to Understanding, Assessing, and Implementing the Strategy That Yields Bottom-Line Success*, John Wiley & Sons, Inc., New York.
Bryman, A. and Bell, E. (2015), *Business Research Methods*, Oxford university press. 4th ed.
Bubshait, A.A. and Al-Dosary, A.A. (2014), 'Application of Lean Six-Sigma Methodology to Reduce the Failure Rate of Valves at Oil Field', *the World Congress on Engineering and Computer Science (WCECS)*, San Francisco, USA, pp. 22–24.
Bubshait, A.A. and Al-Hamdan, H.A. (2013), 'Optimizing Vender Inspectors' Qualification Process Using Lean Six Sigma', *the World Congress on Engineering and Computer Science (WCECS)*, San Francisco, USA, pp. 23–25.
Buch, K. and Rivers, D. (2001), 'TQM: the role of leadership and culture', *Leadership & Organization Development Journal*, Vol. 22 No. 8, pp. 365–371.
Buch, K. and Tolentino, A. (2006), 'Employee perceptions of the rewards associated with six sigma', *Journal of Organizational Change Management*, Vol. 19 No. 3, pp. 356–364.
Burcher, P.G., Lee, G.L. and Waddell, D. (2010), 'Quality lives on": quality initiatives and practices in Australia and Britain', *The TQM Journal*, Vol. 22 No. 5, pp. 487–498.
Burke, J. and Onwuegbuzie, A.J. (2004), 'Mixed Methods Research: A Research Paradigm Whose Time Has Come', *Educational Researcher*, Vol. 33 No. 7, pp. 14–26.
Cameron, R. (2011), 'Mixed methods research: The five Ps framework', *The Electronic Journal of Business Research Methods*, Vol. 9 No. 2, pp. 96–108.
Chakrabarty, A. and Chuan, T.K. (2009), 'An exploratory qualitative and quantitative analysis of Six Sigma in service organizations in Singapore', *Management Research News*, Vol. 32 No. 7, pp. 614–632.
Chakrabarty, A. and Chuan Tan, K. (2007), 'The current state of six sigma application in services', *Managing Service Quality: An International Journal*, Vol. 17 No. 2, pp. 194–208.

Chakravorty, S. (2009), 'Six Sigma programs: An implementation model', *International Journal of Production Economics*, Vol. 119 No. 1, pp. 1–16.
Chakravorty, S.S. and Shah, A.D. (2012), 'Lean Six Sigma (LSS): an implementation experience', *European Journal of Industrial Engineering*, Vol. 6 No. 1, pp. 118–137.
Chen, H., Lindeke, R.R. and Wyrick, D.A. (2010), 'Lean automated manufacturing: avoiding the pitfalls to embrace the opportunities', *Assembly Automation*, Vol. 30 No. 2, pp. 117–123.
Chen, M. and Lyu, J. (2009), 'A Lean Six-Sigma approach to touch panel quality improvement', *Production Planning & Control*, Vol. 20 No. 5, pp. 445–454.
Chiarini, A. (2011), 'Japanese total quality control, TQM, Deming's system of profound knowledge, BPR, Lean and Six Sigma: Comparison and discussion', *International Journal of Lean Six Sigma*, Vol. 2 No. 4, pp. 332–355.
Chiarini, A. (2013), 'Relationships between total quality management and Six Sigma inside European manufacturing companies: a dedicated survey', *International Journal of Productivity and Quality Management*, article,Vol. 11 No. 2, pp. 179–194.
Choo, A.S., Linderman, K.W. and Schroeder, R.G. (2007a), 'Method and context perspectives on learning and knowledge creation in quality management', *Journal of Operations Management*, article,Vol. 25 No. 4, pp. 918–931.
Choo, A.S., Linderman, K.W. and Schroeder, R.G. (2007b), 'Method and psychological effects on learning behaviors and knowledge creation in quality improvement projects', *Management Science*, Vol. 53 No. 3, pp. 437–450.
Choudhury, A. (2012), 'Are You Ready? How to Conduct a Maturity Assessment', *isixsigma*, Available at: http://www.isixsigma.com/new-to-six-sigma/getting-started/are-you-ready-how-conduct-maturity-assessment/.
Collis, J. and Hussey, R. (2003), *Business Research: a practical guide for undergraduate and postgraduate students*, Basingstoke: Palgrave Macmillan, New York, 2nd ed.
Collis, J. and Hussey, R. (2013), *Business Research: A Practical Guide for Undergraduate and Postgraduate Students*, Palgrave Macmillan, New York, 5th ed.
Cooper, D.R. and Schindler, P.S. (2008), *Business Research Methods*, McGraw-Hill Higher Education, 10th ed.
Corbett, L.. (2011), 'Lean Six Sigma: the contribution to business excellence', *International Journal of Lean Six Sigma*, Vol. 2 No. 2, pp. 118–131.
Coronado, R.B. and Antony, J. (2002), 'Critical success factors for the successful implementation of six sigma projects in organisations', *The TQM Magazine*, Vol. 14 No. 2, pp. 92–99.
Creasy, T. and Ramey, S. (2013), 'Don't Lose Patients', *Quality Progress*, Vol. 46 No. 2, pp. 42–49.
Cronemyr, P. and Danielsson, M. (2013), 'Process Management 1-2-3 – a maturity model and diagnostics tool', *Total Quality Management & Business Excellence*, Vol. 24 No. 7–8, pp. 933–944.
Croom, S. (2009), 'introduction to research methodology in operations management', in Karlsson, C., *Researching Operations Management*, Routledge, New York, pp. 42–83.
Crosby, P.B. (1979), *Quality is Free: The Art of Making Quality Certain*, McGraw-Hill, New York.
Curry, A. and Kadasah, N. (2002), 'Focusing on key elements of TQM – evaluation for sustainability', *The TQM Magazine*, Vol. 14 No. 4, pp. 207–216.
Dahlgaard, J.J. and Dahlgaard-Park, S.M. (2006), 'Lean Production, Six Sigma Quality, TQM and Company Culture', *The TQM Magazine*, Vol. 18 No. 3, pp. 263–281.
Dale, B.G. and Lascelles, D.M. (1997), 'Total quality management adoption: revisiting the levels', *The TQM Magazine*, Vol. 9 No. 6, pp. 418–428.

Dale, B.G., Wiele, T. van der and Iwaarden, J. van. (2007), *Managing Quality*, John Wiley & Sons, USA, 5th ed.
Davis, P.J. (2015), 'Implementing an employee career-development strategy: How to build commitment and retain employees', *Human Resource Management International Digest*, Vol. 23 No. 4, pp. 28–32.
Delgado, C., Ferreira, M. and Branco, M.C. (2010), 'The implementation of lean Six Sigma in financial services organizations', *Journal of Manufacturing Technology Management*, Vol. 21 No. 4, pp. 512–523.
Deming, W.E. (1986), *Out of the crisis*, MA: Advanced, Massachusetts Institute of Technology. Center for Study., Engineering, Cambridge.
Denscombe, M. (2008), 'Communities of Practice', *Journal of Mixed Methods Research*, Vol. 2 No. 3, pp. 270–283.
Denzin, N.K. and Lincoln, Y.S. (2011), *Handbook of Qualitative Research*, Sage Publication, London, UK, 4th ed.
Devi, V.R. (2009), 'Employee engagement is a two-way street', *Human Resource Management International Digest*, Vol. 17 No. 2, pp. 3–4.
Does, R.J.M.M., Mast, J. de and Schoonhoven, M. (2015), 'Discussion of "An Emerging Science of Improvement in Health Care"', *Quality Engineering*, Vol. 27 No. 1, pp. 35–40.
Douglas, A., Douglas, J. and Ochieng, J. (2015), 'Lean Six Sigma implementation in East Africa: findings from a pilot study', *The TQM Journal*, Vol. 27 No. 6, pp. 772–780.
Drohomeretski, E., Gouvea da Costa, S.E., Pinheiro de Lima, E. and Garbuio, P.A.D.R. (2013), 'Lean, Six Sigma and Lean Six Sigma: an analysis based on operations strategy', *International Journal of Production Research*, Vol. 52 No. 3 , pp. 1–21.
Drummond, H. and Al-Anazi, F.B. (1997), 'Leadership Styles in Saudi-Arabia: Public and Private Sector Organisations Compared', *Cross Cultural Management: An International Journal*, Vol. 4 No. 4, pp. 3–8.
Duarte, B., Montgomery, D., Fowler, J. and and Konopka, J. (2012), 'Deploying LSS in a global enterprise – project identification', *International Journal of Lean Six Sigma*, Vol. 3 No. 3, pp. 187–205.
Dubois, A. and Gadde, L.-E. (2002), 'Systematic combining: an abductive approach to case research', *Journal of Business Research*, Vol. 55 No. 7, pp. 553–560.
Easterby-Smith, M. and Lyles, M.A. (2011), *Handbook of Organizational Learning and Knowledge Management*, John Wiley & Sons, USA, 2nd ed.
Easterby-Smith, M., Thorpe, R. and Lowe, A. (1991), *Management Research: An Introduction*, Sage Publications, London.
Easterby-Smith, M., Thorpe, R. and Lowe, A. (2012), *Management Research-An Introduction*, Sage Publication, London, UK, 4th ed.
Easton, G. (2010), 'Critical realism in case study research', *Industrial Marketing Management*, article, , Vol. 39 No. 1, pp. 118–128.
Eisenhardt, K.M. (1989a), 'Agency Theory: An Assessment and Review', *Academy of Management Review*, Vol. 14 No. 1, pp. 57–74.
Eisenhardt, K.M. (1989b), 'Building Theories from Case Study Research', *Academy of Management Review*, Vol. 14 No. 4, pp. 532–550.
Erdmann, T.P., de Groot, M. and Does, R.J.M.M. (2010), 'Quality Quandaries: Improving the Invoicing Process of a Consulting Company', *Quality Engineering*, Vol. 22 No. 3, pp. 214–221.
Erdmann, T.P., Janssen, W.W.L.. and Does, R.J.M.M. (2013), 'Quality Quandaries: Streamlining the Procurement Process at a Media and Entertainment Company', *Quality Engineering*, Vol. 25 No. 4, pp. 455–460.

Eriksson, P. and Kovalainen, A. (2008), *Qualitative Methods in Business Research*, Sage Publication Limited, London, UK, 1st ed.
El Faiomy, M.A. and Shaban, A.A.M. (2012), 'Improving waiting time in vaccination room using Lean Six Sigma methodology', *Saudi Ministry of Health*.
Fazzari, A.J. and Levitt, K. (2008), 'Human resources as a strategic partner: Sitting at the table with Six Sigma', *Human Resource Development Quarterly*, Vol. 19 No. 2, pp. 171–180.
Feng, Q. (May) and Manuel, C.M. (2008), 'Under the knife: a national survey of six sigma programs in US healthcare organizations', *International Journal of Health Care Quality Assurance*, Vol. 21 No. 6, pp. 535–547.
Feng, Q. and Manuel, C. (2007), 'Under the knife: a national survey of six sigma programs in US healthcare organizations', *International Journal of Health Care Quality Assurance*, Vol. 21 No. 6, pp. 535–547.
Fiol, C.M. and Lyles, M.A. (1985), 'Organizational Learning', *The Academy of Management Review*, Vol. 10 No. 4, pp. 803–813.
Fleetwood, S. and Ackroyd, S. (2004), *Critical Realist Applications in Organisation and Management Studies*, Critical Realism, Routledge, New York.
Folaron, J. and Chase, J.P.M. (2003), 'The Evolution of Six Sigma', *Six Sigma Forum Magazine*, Vol. 2 No. 4, pp. 38–44.
Fornari, A. and Maszle, G. (2004), 'Lean Six Sigma Leads Xerox', *Six Sigma Forum Magazine*, Vol. 3 No. 4, pp. 11–16.
Forza, C. (2002), 'Survey research in operations management: a process-based perspective', *International Journal of Operations & Production Management*, Vol. 22 No. 2, pp. 152–194.
Forza, C. (2009), 'Surveys', in Karlsson, C., *Researching Operations Management*, Routledge, New York, pp. 84–161.
Franchetti, M. (2014), 'Continuous improvement and facility redesign through the lean DMAIC Six Sigma approach: a final assembly work unit case study from Ohio, USA', *International Journal of Six Sigma and Competitive Advantage*, Vol. 8 No. 2, pp. 83–94.
Franchetti, M. and Barnala, P. (2013), 'Lean six sigma at a material recovery facility: a case study', *International Journal of Lean Six Sigma*, Vol. 4 No. 3, pp. 251–264.
Franchetti, M. and Yanik, M. (2011), 'Continuous improvement and value stream analysis through the Lean DMAIC Six Sigma approach: a manufacturing case study from Ohio, USA', *International Journal of Six Sigma and Competitive Advantage*, Vol. 6 No. 4, pp. 278–300.
Frey, J.H. and Oishi, S.M. (1995), *How to conduct interviews by telephone and in person*, Sage, Thousand Oaks, CA.
Freytag, P. V and Hollensen, S. (2001), 'The process of benchmarking, benchlearning and benchaction', *The TQM Magazine*,Vol. 13 No. 1, pp. 25–34.
Fryer, K., Ogden, S. and Anthony, J. (2013), 'Bessant's continuous improvement model: revisiting and revising', *International Journal of Public Sector Management*, Vol. 26 No. 6, pp. 481–494.
Furterer, S. and Elshennawy, A.K. (2005), 'Implementation of TQM and lean Six Sigma tools in local government: a framework and a case study', *Total Quality Management & Business Excellence*, Vol. 16 No. 10, pp. 1179–1191.
Gable, G.G. (1994), 'Integrating case study and survey research methods: an example in information systems', *European Journal of Information Systems*, Vol. 3 No. 2, pp. 112–126.
Ganesh, L. and Mehta, A. (2010), 'Critical Failure Factors in Enterprise Resource Planning Implementation at Indian SMEs', *Asian Journal of Management Research*, Vol. 1 No. 1,

pp. 44–57.
García-Mireles, G.A., Moraga, M.A. and García, F. (2012), ‘Development of Maturity Models: A Systematic Literature Review’, *Proceedings of the EASE 2012*, Published by the IET, ISBN 978-1-84919-541-6.
Garg, P. and Garg, A. (2013), ‘An empirical study on critical failure factors for enterprise resource planning implementation in Indian retail sector’, *Business Process Management Journal*, Vol. 19 No. 3, pp. 496–514.
Garvin, D.A. (1993), ‘Building a learning organization’, *Harvard Business Review*, Vol. 71 No. 4, pp. 78–91.
Garvin, D., Edmondson, A. and Gino, F. (2008), ‘Is Yours a Learning Organization?’, *Harvard Business Review*, No. March.
GAS. (2015), ‘General Authority for Statistics’, Available at: http:// www.cdsi. gov.sa/en/ economic-statistics (accessed 22 May 2016).
Gay, L.R. and Diehl, P.L. (1992), *Research Methods for Business and Management*, Macmillan Publishing Company, Pennsylvania State University, USA.
GE. (1997), *General Electric Company Annual Report*.
George, M.L. (2003a), *Lean Six Sigma for Service*, McGraw-Hill Companies, Inc., USA, doi:10.1036/0071436359.
George, M.L. (2003b), *How to Use Lean Speed and Six Sigma Quality to Improve Services and Transactions*, McGraw-Hill, New York, NY.
George, M.L., Rowlands, D., Price, M. and Maxey, J. (2005), *The Lean Six Sigma Pocket Toolbook*, McGraw-Hill, New York, USA.
Gijoa, E.V., Scariab, J. and Antony, J. (2011), ‘Application of Six Sigma methodology to reduce defects of a grinding process’, *Quality and Reliability Engineering International*, Vol. 27 No. 8, pp. 1221–1234.
Gitlow, H. and Levine, D. (2004), *Six Sigma for Green Belts and Champions: Foundations, DMAIC, Tools and Methods, Cases and Certification*, Prentice-Hall Publishers, Saddle River, NJ.
Gitlow, H.S. (1994), ‘A Comparison of Japanese Total Quality Control and Deming’s Theory of Management’, *The American Statistician*,Vol. 48 No. 3, pp. 197–203.
Gitlow, H.S. (2009), *A Guide to Lean Six Sigma Management Skills*, Taylor & Francis group, New York.

Glasgow, J.M., Caziewell, S., Jill, R. and Kaboli, P.J. (2010), ‘Guiding inpatient quality improvement: a systematic review of Lean and Six Sigma’, *Joint Commission Journal on Quality and Patient Safety*, Vol. 36 No. 12, pp. 23–45.
Goh, N.H. (2010), ‘Six Sigma in industry: some observations after twenty-five years’, *Quality and Reliability Engineering International*, Vol. 27 No. 2, pp. 221–227.
Gremyr, I. and Raharjo, H. (2013), ‘Quality function deployment in healthcare: a literature review and case study’, *International Journal of Health Care Quality Assurance*, Vol. 26 No. 2, pp. 135–146.
Guba, E.G. and Lincoln, Y.S. (1994), ‘Competing paradigms in qualitative research.’, *Handbook of qualitative research*, Chicago, 2nd ed., pp. 163–194.
Gupta, M.C. and Boyd, L.H. (2008), ‘Theory of constraints: a theory for operations management’, *International Journal of Operations & Production Management*, article, Vol. 28 No. 10, pp. 991–1012.
Gupta, P. (2005), *The Six Sigma Performance Handbook: A Statistical Guide to Optimizing Results*, McGraw-Hill, New York, USA.
Gupta, V., Acharya, P. and Patwardhan, M. (2012), ‘Monitoring quality goals through lean Six-Sigma insures competitiveness’, *International Journal of Productivity and*

Performance Management, Vol. 61 No. 2, pp. 194–203.
Gurumurthy, A. and Kodali, R. (2011), 'Design of lean manufacturing systems using value stream mapping with simulation: A case study', *Journal of Manufacturing Technology Management*, Vol. 22 No. 4, pp. 444–473.
Hardeman, J., and Goethals, P.L. (2011), 'A case study: applying Lean Six Sigma concept to design more efficient airfoil extrusion shimming process', *International Journal of Six Sigma and Competitive Advantage*, Vol. 6 No. 3, pp. 173–196.
Harlan, J., Arnason, W., Nichols, J. and Arthur, J. (2015), 'Roadmap to Savings', *Quality Progress*, Vol. 48 No. 2, pp. 18-25.
Harris, L. (2001), 'Rewarding employee performance: line managers' values, beliefs and perspectives', *The International Journal of Human Resource Management*, Vol. 12 No. 7, pp. 1182–1192.
Harrison, A. and Storey, J. (1996), 'New wave manufacturing strategies: Operational, organizational and human dimensions', *International Journal of Operations & Production Management*, Vol. 16 No. 2, pp. 63 – 76.
Harry, M. and Crawford, J.D. (2004), 'Six sigma for the little guy', *Mechanical Engineering*, Vol. 126 No. 11, pp. 8–10.
Harry, M. and Schroeder, R. (2000), *Six Sigma - The Breakthrough Management Strategy Revolutionizing the World's Top Corporations,* Doubleday, New York, USA.
Harry, M.J. (1998), 'Six Sigma: A Breakthrough Strategy for Profitability', *Quality Progress*, Vol. 31 No. 5, pp. 60–64.
Harry, M.J., Mann, P.S., Hodgins, O. de, Lacke, C. and Hulbert, R. (2010), *Practitioner's Guide for Statistics and Lean Six Sigma for Process Improvments*, John Wiley & Sons, Inc., Hoboken, New Jersy.
Harry, M.J. and Schroeder, R.R. (2005), *Six Sigma: The Breakthrough Management Strategy Revolutionizing the World's Top Corporations*, Currency, New York
'Harzing'. (2013), Available at: http://www.harzing.com/download/jql_journal.pdf/ (accessed 16 January 2013).
Henderson, K.M. and Evans, J.R. (2000), 'Successful implementation of Six Sigma: benchmarking General Electric Company', *Benchmarking: An International Journal*, Vol. 7 No. 4, pp. 260–282.
Hensley, R.L. and Dobie, K. (2005), 'Assessing readiness for six sigma in a service setting', *Managing Service Quality: An International Journal*, Vol. 15 No. 1, pp. 82–101.
Herzberg, F. (1959), *The motivation to work*, Wiley, New York, USA
Herzberg, F., Mausner, B. and Snyderman, B.B. (2011), *The Motivation to Work*, Organization and Business, Transaction Publishers, New Brunswick.
Hess, J.D. and Benjamin, B.A. (2015), 'Applying Lean Six Sigma within the university: opportunities for process improvement and cultural change', *International Journal of Lean Six Sigma*, Vol. 6 No. 3, pp. 249–262.
Hilton, R.J. and Sohal, A. (2012), 'A conceptual model for the successful deployment of Lean Six Sigma', *International Journal of Quality & Reliability Management*, Vol. 29 No. 1, pp. 54–70.
Hines, P., Francis, M. and Found, P. (2006), 'Towards lean product lifecycle management: A framework for new product development', *Journal of Manufacturing Technology Management*, Vol. 17 No. 7, pp. 866–887.
Hines, P., Holweg, M. and Rich, N. (2004), 'Learning to evolve: a review of contemporary lean thinking', *International Journal of Operations & Production Management*, Vol. 24 No. 10, pp. 994–1011.
Ho, Y.C., Chang, O.C. and Wang, W.B. (2008), 'An empirical study of key success factors for Six Sigma Green Belt projects at an Asian MRO company', *Journal of Air Transport*

Management, Vol. 14 No. 5, pp. 263–269.
Hoerl, R. (2001), 'Six Sigma Black Belts: what do they need to know?', *Journal of Quality Management*, Vol. 33 No. 4, pp. 391–406.
Hoerl, R. and Snee, R. (2012), *Statistical Thinking: Improving Business Performance*, SAS Institute Inc., Cary, North Carolina, USA, 2nd ed.
Hoerl, R.W. and Gardner, M.M. (2010), 'Lean Six Sigma, creativity, and innovation', *International Journal of Lean Six Sigma*, Vol. 1 No. 1, pp. 30–38.
Hoggerl, M. and Sehorz, B. (2006), *An Introduction to CMMI and its Assessment Procedure*, Seminar for Computer Science, Salzburg.
Hopp, W.J. and Spearman, M.. (2004), 'To pull or not to pull: what is the question?', *Manufacturing & Service Operations Management*, Vol. 6 No. 2, pp. 133–148.
Hu, G., Wang, L., Fetch, S. and Bidanda, B. (2008), 'A multi-objective model for project portfolio selection to implement lean and Six Sigma concepts', *International Journal of Production Research*, Vol. 46 No. 23, pp. 6611–6625.
Humphrey, W.S. (1989), *Managing the software process*, Addison-Wesley Longman Publishing Co., Boston, MA, USA.
Ingle, S. and Roe, W. (2001), 'Six sigma black belt implementation', *The TQM Magazine*, Vol. 13 No. 4, pp. 273–280.
Jaideep, M., Kumar, A. and Antony, J. (2004), 'A business process change framework for examining the implementation of six sigma: a case study of Dow Chemicals', *The TQM Magazine*, Vol. 16 No. 4, pp. 273–283.
Jeyaraman, J., Teo, L.K. and Soh, K. (2012), 'The perceptions and perspectives of Lean Six Sigma (LSS) practitioners: an empirical study in Malaysia"', *The TQM Journal*, Vol. 24 No. 5, pp. 433–446.
Jeyaraman, K. and Teo, L.K. (2010), 'A conceptual framework for critical success factors of lean Six Sigma: implementation on the performance of electronic manufacturing service industry', *International Journal of Lean Six Sigma*, Vol. 1 No. 3, pp. 191–215.
Jørgensen, F., Matthiesen, Rikke Vestergaard; Nielsen, J. and Johansen, J. (2007), 'Lean Maturity, Lean Sustainability', *Advances in Production Management Systems*, pp. 371–378.
Juran, J.M. and Godfrey, A.B. (1988), *Juran's Quality Handbook*, McGraw-Hill, New York, USA, 5th ed.
Karim, A. and Arif-Uz-Zaman, K. (2013), 'A methodology for effective implementation of lean strategies and its performance evaluation in manufacturing organizations', *Business Process Management Journal*, Vol. 19 No. 1, pp. 169–196.
Karlsson, C. (2010), *Researching Operations Management*, Taylor & Francis group, New York.
Karthi, S., Devadasan, S., Selvaraju, K., Sreenivasa, C.G. and Sivaram, N.M. (2014), 'Transforming into a Lean Six Sigma Enterprise Through ISO 9001 Standard-Based Quality Management System', *Journal of Enterprise Transformation*, Vol. 4 No. 2, pp. 100–122.
Karthi, S., Devadasan, S.R. and Murugesh, R. (2011), 'Lean Six Sigma through ISO 9001 standard-based quality management system: an investigation for research', *International Journal of Productivity and Quality Management*, Vol. 8 No. 2, pp. 180–204.
Kemper, B.P.H., Koopmans, M. and Does, R.J.M. (2009), 'Quality Quandaries: The Availability of Infusion Pumps in a Hospital', *Quality Engineering*, Vol. 21 No. 4, pp. 471–477.
Kishore, R., Swinarski, M.., Jackson, E. and Rao, H. (2012), 'A Quality-Distinction Model of IT Capabilities: Conceptualization and Two-Stage Empirical Validation Using CMMi Processes', *IEEE Transactions On Engineering Management*, Vol. 59 No. 3, pp. 457–

469.
Knowles, G. (2011), *Six Sigma*, Graeme Knowledles & Ventus Publishing
Kornfeld, B. and Kara, S. (2013), 'Selection of Lean and Six Sigma projects in industry', *International Journal of Lean Six Sigma*, Vol. 4 No. 1, pp. 4–16.
Krasachol, L., Willey, P.C.T. and Tannock, J.D.T. (1998), 'The progress of quality management in Thailand', *The TQM Magazine*, Vol. 10 No. 1, pp. 40–44.
Kubiak, T.. (2011), 'Six Sigma in the 21st century', *ASQ Six Sigma Forum Magazine*, Vol. 11 No. 1, p. 7.
Kubiak, T.M. (2012), *The Certified Six Sigma Master Black Belt Handbook*, ASQ Quality Press, USA.
Kucner, R.J. (2009), 'Staying seaworthy', *ASQ Six Sigma Forum Magazine*, Vol. 8 No. 2, pp. 25–30.
Kuiper, A., van Raalte, M. and Does, R.J.M.M. (2014), 'Quality Quandaries: Improving the Overall Equipment Effectiveness at a Pharmaceutical Company', *Quality Engineering*, Vol. 26 No. 4, pp. 478–483.
Kumar, M. (2010), *Six Sigma Implementation in UK Manufacturing SMEs: An Exploratory Research*, PhD Thesis, University of Strathclyde.
Kumar, M. and Antony, J. (2008), 'Comparing the quality management practices in UK SMEs', *Industrial Management & Data Systems*, Vol. 108 No. 9, pp. 1153–1166.
Kumar, M. and Antony, J. (2009), 'Multiple case-study analysis of quality management practices within UK Six Sigma and non-Six Sigma manufacturing small- and medium-sized enterprises', *Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture*, Vol. 223, pp. 925–934.
Kumar, M., Antony, J. and Cho, B. (2009a), 'Project selection and its impact on the successful deployment of Six Sigma', *Business Process Management Journal*, Vol. 15 No. 5, pp. 669–686.
Kumar, M., Antony, J. and Douglas, A. (2009b), 'Does size matter for Six Sigma implementation? Findings from the survey in UK SMEs', *The TQM Journal*, Vol. 21 No. 6, pp. 623–635.
Kumar, M., Antony, J., Madu, C.N., Montgomery, D.C. and Park, S.H. (2008a), 'Common myths of Six Sigma demystified', *International Journal of Quality & Reliability Management*, Vol. 25 No. 8, pp. 878 – 895.
Kumar, M., Antony, J., Singh, R.K., Tiwari, M.K. and Perry, D. (2006), 'Implementing the Lean Six Sigma framework in an Indian SME: a case study', *Production Planning Control*, Vol. 17 No. 4, pp. 407–423.
Kumar, M., Antony, J. and Tiwari, M. (2011), 'Six Sigma implementation framework for SMEs – a roadmap to manage and sustain the change', *International Journal of Production Research*, Vol. 49 No. 18, pp. 5449–5467.
Kumar, U.D., Nowicki, D., Ramirez-Marquez, J.E. and Verma, D. (2008b), 'On the optimal selection of process alternatives in a Six Sigma implementation', *International Journal of Production Economics*, Vol. 111 No. 2, pp. 456–467.
Kumar, U.D., Saranga, H., Ramirez-Marquez, J.E. and Nowicki, D. (2007), 'Six sigma project selection using data envelopment analysis', *The TQM Magazine*, Vol. 19 No. 5, pp. 419–441.
Kwak, Y.H. and Anbari, F.T. (2006), 'Benefits, obstacles, and future of six sigma approach', *Technovation*, Vol. 26 No. 5–6, pp. 708–715.
Ladani, L.J., Das, D., Cartwright, J.L., Yenkner, R. and Razmi, J. (2006), 'Implementation of Six Sigma quality system in Celestica with practical examples', *International Journal of Six Sigma and Competitive Advantage*, Vol. 2 No. 1, pp. 69–88.
Lagrosen, Y., Chebl, R. and Tuesta, M.R. (2011), 'Organisational learning and Six Sigma

deployment readiness evaluation: a case study', *International Journal of Lean Six Sigma*, Vol. 2 No. 1, pp. 23–40.
Langabeer, J.R., DelliFraine, J.L., Heineke, J. and Abbass, I. (2009), 'Implementation of Lean and Six Sigma quality initiatives in hospitals: A goal theoretic perspective', *Operations Management Research*, Vol. 2 No. 1–4, pp. 13–27.
Lasa, I.S., de Castro, R. and Laburu, C.O. (2009), 'Extent of the use of Lean concepts proposed for a value stream mapping application', *Production Planning & Control*, Vol. 20 No. 1, pp. 82–98.
Lattuch, F. and Young, S. (2011), 'Young professionals' perceptions toward organizational change', *Leadership & Organization Development Journal*, Vol. 32 No. 6, pp. 605–627.
Laureani, A. and Antony, J. (2010), 'Reducing employees' turnover in transactional services: a Lean Six Sigma case study', *International Journal of Productivity and Performance Management*, Vol. 59 No. 7, pp. 688–700.
Laureani, A. and Antony, J. (2012), 'Standards for Lean Six Sigma certification', *International Journal of Productivity and Performance Management*, Vol. 61 No. 1, pp. 110–120.
Laureani, A., Antony, J. and Douglas, A. (2010), 'Lean six sigma in a call centre: a case study', *International Journal of Productivity and Performance Management*, Vol. 50 No. 8, pp. 757–768.
Lawrence, H. and Miller, M.R. (2015), 'The ATMAE Lean Six Sigma Certification Exam: Why it Matters to You?', *The Journal of Technology, Management, and Applied Engineering*, Vol. 31 No. 3, pp. 2–19.
Lee, K., Tai, C.-T. and Sheen, G.-J. (2013), 'Using LSS to improve the efficiency and quality of a refund process in a logistics center', *International Journal of Lean Six Sigma*, Vol. 4 No. 4, pp. 409–424.
Lee, L. and Wei, C. (2009), 'Reducing mold changing time by implementing Lean Six Sigma', *Quality and Reliability Engineering International*, Vol. 26 No. 4, pp. 387–395.
Lee, T.Y., Wong, W.K. and Yeung, K.W. (2011), 'Developing a readiness self-assessment model (RSM) for Six Sigma for China enterprises', *International Journal of Quality & Reliability Management*, Vol. 28 No. 2, pp. 169–194.
Lewis, S. (2002), *Six Sigma and Its Application by you will quantifiably improve every measure of performance — income , revenue , and customer*, *Educational Foundation*.
Li, T.S. and Lin, L.C. (2011), 'A unified model for the implementation of both CMMI and 6 sigma', *Total Quality Management & Business Excellence*, Vol. 22 No. 4, pp. 407–424.
Liker, J.K. (1997), *Becoming Lean: Inside Stories of U.S. Manufacturers*, Taylor & Francis group, New York.
Liker, J.K. (2004), *The Toyota Way: 14 management Principles from the World's Greatest manufacturer*, McGraw-Hill, New York.
Lim, S.B.A.H. (2016), *An Exploratory Study on Statistical Process Control in the UK Food Industry*, PhD Thesis, Heriot-Watt University.
Lin, L.-C., Li, T.-S. and Kiang, J.P. (2009), 'A continual improvement framework with integration of CMMI and six-sigma model for auto industry', *Quality and Reliability Engineering International*, Vol. 25 No. 5, pp. 551–569.
Lincoln, Y.S. and Guba, E.G. (1985), *Naturalistic inquiry*, Sage, Beverly Hills, CA.
Linderman, K., Schroeder, R.G. and Choo, A.S. (2006), 'Six Sigma: The role of goals in improvement teams', *Journal of Operations Management*, Vol. 24 No. 6, pp. 779–790.
Linderman, K., Schroeder, R.G., Zaheer, S. and Choo, A.S. (2003), 'Six Sigma: a goal-theoretic perspective', *Journal of Operations Management*, Vol. 21 No. 2, pp. 193–203.
Lokkerbol, J., Molenaar, M.F.A. and Does, R.J.M.M. (2012), 'Quality Quandaries: An Efficient Public Sector', *Quality Engineering*, Vol. 24 No. 3, pp. 431–435.

van Looy, A., De Backer, M. and Poels, G. (2011), 'Defining business process maturity. A journey towards excellence', *Total Quality Management & Business Excellence*, Vol. 22 No. 11, doi:10.1080/14783363.2011.624779.

van Looy, A., De Backer, M., Poels, G. and Snoeck, M. (2013), 'Choosing the right business process maturity model', *Information and Management*, Vol. 50 No. 7, pp. 466–488.

Lynch, P., Quigley, J. and Scholarios, D. (2012), *Research Methodology Course Notes*, Strathclyde University, Glasgow.

Mader, D.P. (2003), 'DFSS and your current design process', *Quality Progress*, Vol. 36 No. 7, pp. 88–89.

Mader, D.P. (2007), 'How to Identify and Select Lean Six Sigma Projects', *Quality Progress*, Vol. 40 No. 7, pp. 58–60.

Mader, D.P. (2008), 'Lean Six Sigma's evolution', *Quality Progress*, Vol. 41 No. 1, pp. 40–48.

Magd, H.A.E. (2006), 'An investigation of ISO 9000 adoption in Saudi Arabia', *Managerial Auditing Journal*, Vol. 21 No. 2, pp. 132–147.

Magd, H. and Curry, A. (2003), 'An empirical analysis of management attitudes towards ISO 9001:2000 in Egypt', *The TQM Magazine*, Vol. 15 No. 6, pp. 381–390.

Mahanti, R. and Antony, J. (2006), 'Six Sigma in software industries: some case studies and observations', *International journal of six sigma and competitive advantage*, Vol. 2 No. 3, pp. 263–290.

Maier, A., Moultrie, J. and Clarkson, P.J. (2012), 'Assessing Organizational Capabilities: Reviewing and Guiding the Development of Maturity Grids', *IEEE Transactions on Engineering Management*, Vol. 59 No. 1, pp. 138–159.

Maleyeff, J., Arnheiter, A.E. and Venkateswaran, V. (2012), 'The continuing evolution of Lean Six Sigma', *TQM Journal*, Vol. 24 No. 6, pp. 542–555.

Malmbrandt, M. and Ahlstro, P. (2013), 'An instrument for assessing lean service adoption', *International Journal of Operations & Production Management*, Vol. 33 No. 9, pp. 1131–1165.

Manville, G., Greatbanks, R., Krishnasamy, R. and Parker, D.W. (2012), 'Critical success factors for Lean Six Sigma programmes: a view from middle management', *International Journal of Quality & Reliability Management*, Vol. 29 No. 1, pp. 7–20.

Mariotti, F., Kadasah, N. and Abdulghaffar, N. (2014), 'Motivations and barriers affecting the implementation of ISO 14001 in Saudi Arabia: an empirical investigation', *Total Quality Management & Business Excellence*, Vol. 25 No. 11–12, pp. 1352–1364.

Martin, J.W. (2008), *Lean Six Sigma for the Office*, Series on resource management, CRC Press, New York.

Martinez-Jurado, P.J. and Moyano-Fuentes, J. (2012), 'Key determinants of lean production adoption: evidence from the aerospace sector', *Production Planning & Control: The Management of Operations*, Vol. 25 No. 4, pp. 332–345.

Martins, E.C. and Terblanche, F. (2003), 'Building organisational culture that stimulates creativity and innovation', *European Journal of Innovation Management*, Vol. 6 No. 1, pp. 64–74.

Mason, J. (2002), *Qualitative Researching*, Sage Publications, London, UK.

de Mast, J. and Lokkerbol, J. (2012), 'An analysis of the Six Sigma DMAIC method from the perspective of problem solving', *International Journal of Production Economics*, Vol. 139 No. 2, pp. 604–614.

Matteo, M. (2012), *Development of a sustainable lean six sigma framework in healthcare sector*, PhD Thesis, Sheffield Hallam University.

McAdam, R. and Lafferty, B. (2004), 'A multilevel case study critique of six sigma: statistical control or strategic change?', *International Journal of Operations &*

Production Management, Vol. 24 No. 5, pp. 530–549.
McCormack, K. (2007), *Business process maturity*, Booksurge Publishing, South Carolina, United States.
McGregor, D. (1960), 'The human side of enterprise', *Readings in Managerial Psychology*, University of Chicago Press, New York, pp. 314–324.
MCI. (2015), 'Ministry of Commerce and Investment', Available at: http:// www.mci. gov. sa/ en/Pages/Default.aspx (accessed 10 March 2015).
Medeiros, C.O., Cavalli, S.B., Salay, E. and Proença, R.P.C. (2011), 'Assessment of the methodological strategies adopted by food safety training programmes for food service workers: A systematic review', *Food Control*, Vol. 22 No. 8, pp. 1136–1144.
Meredith, J.R., Raturi, A., Amoako-Gympah, K. and Kaplan, B. (1989), 'Alternative research paradigms in operation', *Journal of Operations Management*, Vol. 8 No. 4, pp. 297–326.
Miles, M.B. and Huberman, A.M. (1994), *Qualitative data analysis: An expanded sourcebook*, Sage Publication, California, USA
MOE. (2015), 'Ministry of Economy, United Arab Emirates', *Annual Statistical Report 2*, Available at: http://www.economy.gov.ae/StatisticsReportsEn/Statistical Report 2014 - 4th Issue.pdf (accessed 22 May 2016).
Montgomery, D.C. (2010), 'A modern framework for achieving enterprise excellence', *International Journal of Lean Six Sigma*, Vol. 1 No. 1, pp. 56–65.
Morgan, G. and Ramirez, R. (1983), 'Action learning: a holographic metaphor for guiding change', *Human Relations*, Vol. 37 No. 1, pp. 1–28.
Murman, E.M. (2011), 'Designing and Deploying Lean Healthcare Curriculum', *Massachusetts Institute of Technology, DSpace*, Available at: https://dspace. mit.edu/ handle/1721.1/84466.
Murugappan, M. and Keeni, G. (2003), 'Blending CMM and Six Sigma to meet business goals', *IEEE Software*, Vol. 20 No. 2, pp. 42–48.
Nabhani, F. and Shokri, A. (2009), 'Reducing the delivery lead time in a food distribution SME through the implementation of six sigma methodology', *Journal of Manufacturing Technology Management*, Vol. 20 No. 7, pp. 957–974.
Nafei, W.A., Khanfar, N.M. and Kaifi, B.A. (2012), 'Leadership styles and organizational learning an empirical study on Saudi banks in Al-Taif Governorate Kingdom of Saudi Arabia', *Journal of Management and Strategy*, Vol. 3 No. 1, p. 2.
Näslund, D. (2008), 'Lean, six sigma and lean sigma: fads or real process improvement methods?', *Business Process Management Journal*, article, , Vol. 14 No. 3, pp. 269–287.
Ndaita, P.M., Gachie, T. and Kiveu, C.W. (2015), 'The implementation of Lean Six Sigma concept at national bank of Kenya-operation division', *The TQM Journal*, Vol. 27 No. 6, pp. 683–690.
Niemeijer, G.C., Trip, A., Ahaus, K.C.T.B., Wendt, K.W. and Does, R.J.M.M. (2012), 'Quality Quandaries: Reducing Overuse of Diagnostic Tests for Trauma Patients', *Quality Engineering*, Vol. 24 No. September, pp. 558–563.
Nightingale, D.J. and Mize, J.H. (2002), 'Development of a Lean Enterprise Transformation Maturity Model', *Information, Knowledge, Systems Management*, Vol. 3 No. 1, pp. 15–30.
Nonthaleerak, P. and Hendry, L.C. (2006), 'Six Sigma: literature review and key future research area', *International Journal of Six Sigma and Competitive Advantage*, Vol. 2 No. 2, pp. 105–161.
Nonthaleerak, P. and Hendry, L.C. (2008), 'Exploring the six sigma phenomenon using multiple case study evidence', *International Journal of Operations & Production*

Management, Vol. 28 No. 3, pp. 279–303.
Noorwali, A. (2013), 'Apply Lean and Taguchi in Different Level of Variability of Food Flow Processing System', *Procedia Engineering*, Vol. 63, pp. 728–734.
Nwabueze, U. (2012), 'Process improvement: the case of a drugs manufacturing company', *Business Process Management Journal*, Vol. 18 No. 4, pp. 576–584.
Oguz, C., Kim, Y.W., Hutchison, J. and Han, S. (2012), 'Implementing Lean Six Sigma: A Case Study in Concrete Panel', *20th Annual Conference of the International Group for Lean Construction*.
Ohno, T. (1988), *Toyota Production System: Beyond Large Scale Production, Productivity Press*, Productivity Press, Portland.
Okoli, C. and Schabram, K. (2010), *A guide to conducting a systematic literature review of information systems research*, Sprouts, Canada.
Olson, D.J. and Sinn, J.W. (2011), 'Measure your Six Sigma program's maturity and find areas to improve', *Quality Progress*, Vol. 44 No. 10, pp. 36–40.
OMG. (2008), 'The OMG Business Process Maturity Model'. Available at: http://www.omg.org/spec/BPMM/.
Al Owad, A., Karim, M.A. and Ma, L. (2012), 'Integrated Lean Six Sigma approach for patient flow improvement in hospital emergency department', *Advanced Materials Research*, Vol. 834–836 No. 19, pp. 1893–1902.
Pamfilie, R., Petcu, A.J. and Draghici, M. (2012), 'The Importance of Leadership in Driving a Strategic Lean Six Sigma Management', *Procedia - Social and Behavioral Sciences*, Vol. 58 No. 8, pp. 187–196.
Panat, R., Dimitrova, V., Selvamuniandy, T.S., Ishiko, K. and Sun, D. (2014), 'The application of Lean Six Sigma to the configuration control in Intel's manufacturing R&D environment', *International Journal of Lean Six Sigma*, Vol. 5 No. 4, pp. 444 – 459.
Pande, P. and and Holpp, L. (2000), *What is Six Sigma?*, McGraw-Hill, New York, USA.
Pande, P.S., Neuman, R.P. and Cavanagh, R.. (2000), *The Six Sigma Way: How GE, Motorola, and Other Top Companies are honing their Performance*, McGraw-Hill, New York, NY.
Panizzolo, R., Garengo, P., Sharma, M.K. and Gore, A. (2012), 'Lean manufacturing in developing countries: evidence from Indian SMEs', *Production Planning & Control: The Management of Operations*, Vol. 23 No. 10–11, pp. 769–788.
Paulk, M.C., Curtis, B., Chrissis, M.B. and Weber, C.V. (1993), 'Capability maturity model', *version 1.1. IEEE Software*, Vol. 10 No. 4, pp. 18–27.
Pedersen, E.R.G. and Huniche, M. (2011), 'Determinants of lean success and failure in the Danish public sector: A negotiated order perspective', *International Journal of Public Sector Management*, Vol. 24 No. 5, pp. 403 – 420.
Pepper, M.P.. and Spedding, T.A. (2010), 'The evolution of Lean Six Sigma', *International Journal of Quality & Reliability Management*, Vol. 27 No. 2, pp. 138–155.
Percin, S. and Kahraman, C. (2010), 'An Integrated Fuzzy Multi-Criteria Decision-Making Approach for Six Sigma Project', *International Journal of Computational Intelligence Systems*, Vol. 3 No. 5, pp. 610–621.
Perry, C. (1998), 'Processes of a case study methodology for postgraduate research in marketing', *European Journal of Marketing*, Vol. 32 No. 9/10, pp. 785–802.
Pickrell, G., Lyons, J. and Shaver, J. (2005), 'Lean Six Sigma implementation case studies', *International Journal of Six Sigma and Competitive Advantages*, Vol. 1 No. 4, pp. 369–379.
Pigosso, D.C.A., Rozenfeld, H. and McAloone, T.C. (2013), 'Ecodesign maturity model: a management framework to support ecodesign implementation into manufacturing

companies', *Journal of Cleaner Production*, Vol. 59 No. 5, pp. 160–173.
Pinto, S.H.B., Carvalho, M.M. and Ho, L.L. (2008), 'Main quality programs characteristics in large size Brazilian companies', *International Journal of Quality & Reliability Management*, Vol. 25 No. 3, pp. 276 – 291.
Polit, D.F. and Beck, C.T. (2004), *Nursing research: Principles and methods*, Williams and Wilkins, Philadelphia, PA, 7th ed.
Prasanna, M. and Vinodh, S. (2013), 'Lean Six Sigma in SMEs: an exploration through literature review', *Journal of Engineering, Design and Technology*, Vol. 11 No. 3, pp. 224–250.
Psychogios, A.G., Atanasovski, J. and Tsironis, L.K. (2012), 'Lean Six Sigma in a service context: A multi-factor application approach in the telecommunications industry', *International Journal of Quality & Reliability Management*, Vol. 29 No. 1, pp. 122 – 139.
Pulakanam, V. (2012), 'Costs and savings of Six Sigma programs: An empirical study', *The Quality Management Journal*, Vol. 19 No. 4, pp. 39–54.
Pullen, W. (2007), 'A public sector HPT maturity model', *Perform Improvement*, Vol. 46 No. 4, pp. 9–15.
Pyzdek, T. (2003), *The Six Sigma Handbook, Revised and Expanded*, Mcgraw-hill.
Pyzdek, T. and Keller, P.A. (2014), *The six sigma handbook*, McGraw-Hill Education.
Qi, E., Shen, J. and Dou, R. (2013), 'Optimizing Six Sigma Processes to Satisfy Customers by TRIZ Innovation Methodology', *Proceedings of 2013 4th International Asia Conference on Industrial Engineering and Management Innovation (IEMI2013)*, SpringerLink : Bücher, Springer Berlin Heidelberg, pp. 753–759.
Raje, P. (2009), 'Six Sigma Maturity Model', *isixsigma,* Available at: https:// www. isixsigma.com/implementation/basics/maturity-model-describes-stages-six-sigma-evolution/.
Rao, K.P. (2010), 'How Can CMMI Help Six Sigma ?', *Software Quality Professional*, Vol. 12 No. 2, pp. 28–38.
Raschke, R.L. and Ingraham, L.R. (2010), *Business Process Maturity's Effect on Performance* (No. 402), AMCIS 2010 Proceedings.
Rasis, D., Gitlow, H.S. and Popovich, E. (2002), 'Paper Organizers International: A Fictitious Six Sigma Green Belt Case Study. I', *Quality Engineering*, Vol. 15 No. 1, pp. 127–145.
Reddy, l. K.V. and Al Shammari, F. (2013), 'Six Sigma Approach on Discharge Process Turnaround time in King Khalid Hospital, Hail, Saudi Arabia', *Australian Journal of Basic & Applied Sciences*, Vol. 7 No. 14, p. 523.
Rey, D. and Neuhäuser, M. (2011), 'Wilcoxon-Signed-Rank Test', in Lovric, M. (Ed.), *International Encyclopedia of Statistical Science*, inbook, Springer Berlin Heidelberg, Berlin, Heidelberg, pp. 1658–1659.
Richard, D.S. (2008), 'How lean is your Six Sigma program?', *ASQ Six Sigma Forum Magazine*, Vol. 27 No. 4, pp. 42–45.
Ringen, G. and Holtskog, H. (2011), 'How enablers for lean product development motivate engineers', *International Journal of Computer Integrated Manufacturing*, Vol. 6 No. 12, pp. 1117–1127.
Robson, C. (2002), *Real World Research: A Resource for Social Scientists and Practitioner-Researchers*, Wiley, New York.
Rockart, J.F. (1979), 'Chief executives define their own data needs', *Harvard Business Review*, Vol. 57 No. 2, pp. 81–92.
Röglinger, M., Pöppelbuß, J. and Becker, J. (2012), 'Maturity models in business process management', *Business Process Management Journal*, Vol. 18 No. 2, pp. 328–346.
Roth, A. V, Marucheck, A.S., Kemp, A. and Trimble, D. (1994), 'The Knowledge Factory

for accelerated learning practices', *Planning Review*, Vol. 22 No. 3, pp. 26–46.

Roth, N. and Franchetti, M. (2010), 'Process improvement for printing operations through the DMAIC Lean Six Sigma approach: a case study from Northwest Ohio, USA', *International Journal of Lean Six Sigma*, Vol. 1 No. 2, pp. 119–133.

Rowlands, H. (2003), 'Six sigma: a new philosophy or repackaging of old ideas?', *Engineering Management Journal*, Vol. 13 No. 2, pp. 18–21.

Rowlands, H. (2004), 'Implementation issues of Six Sigma in an SME', *First International Conference on Six Sigma*, Glasgow, UK, p. 16 and 17.

Ruff, M. (n.d.). 'Hard and Soft Savings: What Counts Can Be Counted', *isixsigma*, Available at: http://www.isixsigma.com/implementation/financial-analysis/hard-and-soft-savings-what-counts-can-be-counted/#comments.

Runeson, P. and Höst, M. (2009), 'Guidelines for conducting and reporting case study research in software engineering', *Empir Software Eng*, Vol. 14, pp. 131–164.

Rungasamy, S., Antony, J. and Ghosh, S. (2002), 'Critical success factors for SPC implementation in UK small and medium enterprises: some key findings from a survey', *The TQM Magazine*, Vol. 14 No. 4, pp. 217–224.

Rungtusanatham, M.J., Choi, T.Y., Hollingworth, D.G., Wu, Z. and Forza, C. (2003), 'Survey research in operations management: historical analyses', *Journal of Operations Management*, Vol. 21 No. 4, pp. 475–488.

Salah, S., Rahim, A. and Carretero, J. (2010), 'The integration of Six Sigma and Lean Management', *International Journal of Lean Six Sigma*, Vol. 1 No. 3, pp. 249–274.

SASO. (2016), 'Saudi Standards, Metrology and Quality Organisation', Available at: http://www.saso.gov.sa/en/Pages/default.aspx

Saunders, M., Lewis, P. and Thornhill, A. (2007), *Research Methods for Business Students*, Prentice Hall, London, UK, 4th ed.

Saunders, M., Thornhill, A. and Lewis, P. (2009), *Research Methods for Business Students*, Pearson Education Limited, Edinburgh, UK, 5th ed.

Savolainen, T. and Haikonen, A. (2007), 'Dynamics of organizational learning and continuous improvement in six sigma implementation', *The TQM Magazine*, Vol. 19 No. 1, pp. 6–17.

Scherrer-Rathje, M., Boyle, T.A. and Deflorin, P. (2009), 'Lean, take two! Reflections from the second attempt at lean implementation', *Business Horizons*, Vol. 52 No. 1, pp. 79–88.

Schoonhoven, M., Kemper, B.P.H., Brilleman, M.I. and Does, R.J.M.M. (2011), 'Quality Quandaries: Streamlining the Path to Optimal Care for Cardiovascular Patients', *Quality Engineering*, Vol. 23 No. 4, pp. 388–394.

Schoonhoven, M., Lubbers, C. and Does, R.J.M.. (2013), 'Quality Quandaries: Shortening the Throughput Time of a Hospital's Billing Process', *Quality Engineering*, Vol. 25 No. 2, pp. 188–193.

Schroeder, R.G., Linderman, K., Liedtke, C. and Choo, A.S. (2008), 'Six Sigma: Definition and underlying theory', *Journal of Operations Management*, Vol. 26 No. 4, pp. 536–554.

Sehwail, L. and DeYong, C. (2003), 'Six Sigma in health care', *International Journal of Health Care Quality Assurance Incorporating Leadership in Health Services*, Vol. 16 No. 4, pp. 1–5.

SEI. (2000), 'CMMI for Systems Engineering/Software Engineering, Version 1.02, Continuous Representation, CMU/SEI-2000- TR-019, ESC-TR-2000- 019, Software Engineering Institute, Carnegie Mellon University, Pittsburgh, PA, 2000.'

SEI. (2005), 'Capability Maturity Model ® Integration (CMMI ®) Overview', *Defense*, pp. 1–58.

Senge, P. (1990), *The Fifth Discipline: the Art and Practice of the Learning Organization*, Doubleday, New York.

Shah, R., Chandrasekaran, a. and Linderman, K. (2008), 'In pursuit of implementation patterns: the context of Lean and Six Sigma', *International Journal of Production Research*, Vol. 46 No. 23, pp. 6679–6699.

Shah, R. and Ward, P.T. (2003), 'Lean manufacturing: context, practice bundles, and performance', *Journal of Operations Management*, Vol. 21 No. 2, pp. 129–149.

Shahin, A. and Alinavaz, M. (2008), 'Integrative approaches and frameworks of lean Six Sigma: a literature perspective', *International Journal of Process Management and Benchmarking*, Vol. 2 No. 4, pp. 323–337.

Shere, K.D. (2003), 'Comparing Lean Six Sigma to the Capability Maturity Model', *The Journal of Defense Software Engineering*, No. September, pp. 9–12.

Silversides, G. (2001), 'Networking and identity: the role of networking in the public image of professional service firms', *Journal of Small Business and Enterprise Development*, Vol. 8 No. 2, pp. 174–184.

Smith, B. (2003), 'Lean and Six Sigma – a one-two punch', *Quality Progress*, Vol. 4 No. 4, pp. 37–41.

Snee, R.D. (2004), 'Six sigma: the evolution of 100 years of business improvement methodology', *International Journal of Six Sigma and Competitive Advantage*, Vol. 1 No. 1, pp. 4–20.

Snee, R.D. (2010), 'Lean Six Sigma – getting better all the time', *International Journal of Lean Six Sigma*, Vol. 1 No. 1, pp. 9–29.

Snee, R.D. and Hoerl, R.W. (2003), *Leading Six Sigma – A Step by Step Guide based on Experience at GE and other Six Sigma companies*, (FT Prentice-Hall,Ed.), NJ, USA.

Snee, R.D. and Hoerl, R.W. (2005), *Six Sigma beyond the factory floor*, Pearson Prentice Hall, USA.

Snee, R.D. and Hoerl, R.W. (2007), 'Integrating Lean and Six Sigma – a holistic approach', *ASQ Six Sigma Forum Magazine*, Vol. 6 No. 3, pp. 15–21.

Snee, R.D., Jr, R. and F, W. (2002), 'The project selection process', *Quality Progress*, Vol. 35 No. 9, p. 78.

Sony, M. and Naik, S. (2012), 'Six Sigma, organizational learning and innovation: An integration and empirical examination', *International Journal of Quality & Reliability Management*, Vol. 29 No. 8, pp. 915–936.

SQC. (2016), 'The Saudi Quality Council', Available at: http://www.sqc.org.sa/ index.php?lang=en (accessed 16 May 2016).

Srinivasan, S. and Murthy, M.A.N. (2010), 'Process Maturity Model Can Help Give a Business an Edge', *isixsigma*, available at: https://www. isixsigma.com/ methodology/ business-process-management-bpm/process-maturity-model-can-help-give-business-edge/ (accessed 23 June 2016).

SSQ. (2016), 'Saudi Society for Quality', available at: http://ssq.org.sa (accessed 16 May 2016).

Stone, K.B. (2012), 'Four decades of lean: a systematic literature review', *International Journal of Lean Six Sigma*, Vol. 3 No. 2, pp. 112–132.

Su, C.-T. and Chou, C.-J. (2008), 'A systematic methodology for the creation of Six Sigma projects: A case study of semiconductor foundry', *Expert Systems with Applications*, Vol. 34 No. 4, pp. 2693–2703.

Suresh, S., Antony, J., Kumar, M. and Douglas, A. (2012), 'Six Sigma and leadership: some observations and agenda for future research', *The TQM Journal*, Vol. 24 No. 3, pp. 231 – 247.

Svensson, C., Antony, J., Ba-Essa, M., Bakhsh, M. and Albliwi, S. (2015), 'A Lean Six

Sigma program in higher education', *International Journal of Quality & Reliability Management*, Vol. 32 No. 9, pp. 951–969.

Taghawi-Nejad, D. (2015), 'Saudis and Expats: An Agent-Based Model of the Saudi Arabian Labor Market', *Advances in Artificial Economics*, Vol. 676 No. October, pp. 139–149.

Taghizadegan, S. (2006), *Essentials of Lean Six Sigma*, Butterworth-Heinemann, Oxford, UK.

Taner, M.T., Sezen, B. and Antony, J. (2007), 'An overview of six sigma applications in healthcare industry', *International Journal of Health Care Quality Assurance*, Vol. 20 No. 4, pp. 329–340.

Tashakkori, A. and Creswell, J. (2007), 'Exploring the Nature of Research Questions in Mixed Methods Research', *Journal of Mixed Methods Research*, Vol. 1 No. 3, pp. 207–211.

Tashakkori, A. and Teddlie, C. (2010), *SAGE Handbook of Mixed Methods in Social & Behavioral Research*.s London: SAGE Publications.

Tatikonda, L.. (2008), 'A Less Costly Billing Process Using lean Six Sigma to reduce errors', *Quality Progress*, Vol. 41 No. 1, pp. 31–39.

Taylor, F.W. (2004), *Scientific Management*, Taylor & Francis group, New York.

Tellis, W. (1997), 'Introduction to case study. The Qualitative Report', *On-line serial*, available at: http://www.nova.edu/ssss/QR/QR3-2/tellis1.html (accessed 10 September 2014).

Thomas, A., Barton, R. and Okafor, C. (2009), 'Applying lean six sigma in a small engineering company – a model for change', *Journal of Manufacturing Technology Management*, Vol. 20 No. 1, pp. 113–129.

Thomas, A.J., Ringwald, K., Parfitt, S., Davies, A. and John, E. (2014), 'An empirical analysis of Lean Six Sigma implementation in SMEs – a migratory perspective', *International Journal of Quality & Reliability Management*, Vol. 31 No. 8, pp. 888–905.

Thomas, A.J., Rowlands, H., Byard, P. and Rowland-Jones, R. (2008), 'Lean Six Sigma: an integrated strategy for manufacturing sustainability', *International Journal of Six Sigma and Competitive Advantage*, Vol. 4 No. 4, pp. 333–354.

Thomas, B.H., Ciliska, D., Dobbins, M. and Micucci, S. (2004), 'A process for systematically reviewing the literature: providing the research evidence for public health nursing interventions', *Worldviews on Evidence- based Nursing*, Vol. 1 No. 3, pp. 176–184.

Timans, W., Antony, J., Ahaus, K. and Solingen, R. (2012), 'Implementation of Lean Six Sigma in small and medium-sized manufacturing enterprises in the Netherlands', *Journal of Operational Research Society*, Vol. 63, pp. 339–353.

Timans, W., Antony, J., Ahaus, K. and van Solingen, R. (2011), 'Implementation of Lean Six Sigma in small- and medium-sized manufacturing enterprises in the Netherlands', *Journal of the Operational Research Society*, Vol. 63 No. 3, pp. 339–353.

Tjahjono, B., Ball, P., V., Itanov, V.I., Scorzafave, C., Nogueira, J., Calleja, J., Minguet, M., et al. (2010), 'Six Sigma: a literature review', *International Journal of Lean Six Sigma*, Vol. 1 No. 3, pp. 216–233.

Tranfield, D., Denyer, D. and Smart, P. (2003), 'Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review', *British Journal of Management*, Vol. 14 No. 3, pp. 207–222.

Valadão, A.F.C., Turrioni, J.B. and Campos, P.H.S. (2013), 'Relationship between the maturity of continuous improvement and the certification of quality management system in automotive sector in Brazil', *Independent Journal Of Management & Production*, Vol. 4 No. 1, pp. 1–11.

Valmohammadi, C. and Roshanzamir, S. (2014), 'The guidelines of improvement: Relations among organizational culture, TQM and performance', *International Journal of*

Production Economics, Vol. 164, pp. 167–178.
De Vaus, D. (2001), *Research design in social research*, Sage, London.
Verschuren, P. (2003), 'Case study as a research strategy: Some ambiguities and opportunities', *International Journal of Social Research Methodology*, Vol. 6 No. 2, pp. 121–139.
Vinodh, S., Gautham, S.G. and Ramiya, A. (2011), 'Implementing lean sigma framework in an Indian automotive valves manufacturing organisation: a case study', *Production Planning & Control*, Vol. 22 No. 7, pp. 708–722.
Vinodh, S., Kumar, S.V. and Vimal, K.E.K. (2012), 'Implementing Lean Sigma in an Indian rotary switches manufacturing organisation', *Production Planning & Control*, Vol. 25 No. 4, pp. 1–15.
Vision 2030. (2016), available at: http://vision2030.gov.sa/en/foreword, (accessed 30 April 2016).
Voehl, F., Harrington, H.J., Mignosa, C. and Charron, R. (2013), *The Lean Six Sigma Black Belt Handbook: Tools and Methods for Process Acceleration*, Taylor & Francis group, New York.
Voss, C. (2009), 'Case Research in Operations Management', in Karlsson, C. (Ed.), *Researching Operations Management*, Routledge, NY, pp. 162–195.
Voss, C., Tsikriktsis, N. and Frohlich, M. (2002), 'Case Research in Operations Management', *International Journal of Operations & Production Management*, Vol. 22 No. 2, pp. 195–219.
Walley, P. (2014), 'Adaptation and implementation of improvement methods in a Middle Eastern hospital', *Production and Operations Management Society 25th Annual Conference*, Atlanta, USA.
Walters, L. (2005), 'Six Sigma: is it really different?', *Quality and Reliability Engineering International*, Vol. 21 No. 3, pp. 221–224.
Wang, F.-K. and Chen, K.-S. (2012), 'Application of Lean Six Sigma to a panel equipment manufacturer', *Total Quality Management & Business Excellence*, Vol. 23 No. 4, pp. 417–429.
Wang, M.-T., Wan, H.-D., Chen, H.-Y., Wang, S.-M.A., Huang, S.-C.A. and Cheng, H.-Y.L. (2012), 'Six Sigma and Lean Six Sigma: a literature review and experience in Taiwan', *International Foundation for Production Research-Asia Pacific Region*, Patong Beach, Phuket.
Watson- Hemphill, K. and Bradley, K. (2012), 'Does Your Deployment Measure Up? Presenting a Maturity Model for Lean Six Sigma', *The quality management forum*, Vol. 38 No. 3, pp. 1–8.
Watson, G.H. (2001), 'Cycles of Learning: Observations of Jack Welch', *Six Sigma Forum Magazine*, Vol. 1 No. 2, pp. 13–17.
Watson, G.H. (2002), 'Breakthrough in Delivering Software Quality: CMM and Six Sigma', *Software Quality — ECSQ*, Springer Berlin Heidelberg, Vol. 2349 No May, pp. 36–41.
Wendler, R. (2012), 'The maturity of maturity model research: A systematic mapping study', *Information and Software Technology journal*, Vol. 45 No. 12, pp. 1317–1339.
Westbrook, R. (1994), 'Priority Management: New Theory for Operations Management', *International Journal of Operations & Production Management*, Vol. 14 No. 6, pp. 4–24.
Wijma, J., Trip, A., Does, R. and Bisgaard, S. (2009), 'Quality Quandaries: Efficiency Improvement in a Nursing Department', *Quality Engineering*, Vol. 21 No. 2, pp. 222–228.
Wiklund, H. and Wiklund, P.S. (2002), 'Widening the Six Sigma concept: An approach to improve organizational learning', *Total Quality Management*, Vol. 13 No. 2, pp. 233–

239.
Wiley, C. (1997), 'What motivates employees according to over 40 years of motivation surveys', *International Journal of Manpower*, Vol. 18 No. 3, pp. 263–280.
William, H. and Willie, K. (2003), 'The Honeywell experience', *ASQ Six Sigma Forum Magazine*, Vol. 2 No. 2, pp. 34–37.
Wilson, F. (2015), 'The Quality Maturity Model: your roadmap to a culture of quality', *Library Management*, Vol. 36 No. 3, pp. 258–267.
Womack, J.P. and Jones, D.T. (2003), *Lean Thinking: Banish Waste and Create Wealth in Your Corporation*, Simon & Schuster, London, UK, 2nd ed.
Womack, J.P. and Jones, D.T. (2005), 'Lean consumption', *Harvard Business Review*, Vol. 83 No. 3, pp. 58–69.
Womack, J.P., Jones, D.T. and Roos, D. (1990), *The machine that changed the world*, Rawson Associates/Macmillan Publishing Company, New York, USA.
Worley, J.M. and Doolen, T.L. (2006), 'The role of communication and management support in a lean manufacturing implementation', *Management Decision*, Vol. 44 No. 2, pp. 228 – 245.
Xiaofen, T. (2013), 'Investigation on quality management maturity of Shanghai enterprises', *The TQM Journal*, Vol. 25 No. 4, pp. 417–430.
Yang, C.-C. (2004), 'An integrated model of TQM and GE-Six-Sigma', *International Journal of Six Sigma and Competitive Advantage*, Vol. 1 No. 1, pp. 97–111.
Yeo, K.T. (2002), 'Critical failure factors in information system projects', *International Journal of Project Management*, Vol. 20 No. 3, pp. 241–246.
Yi, T.P., Feng, C.J., Prakash, J. and Ping, L.W. (2012), 'Reducing electronic component losses in lean electronics assembly with Six Sigma approach', *International Journal of Lean Six Sigma*, Vol. 3 No. 3, pp. 206–230.
Yin, R.K. (1994), *Case Study Research - Design and Methods. Applied Social Research methods Series*, CA: Newbury Park, 2nd ed.
Yin, R.K. (2003a), *Case Study Research: Design and Methods*, Sage Publications, Inc, California, USA, 3rd ed.
Yin, R.K. (2003b), *Applications of Case Study Research*, Sage Publications, Inc, California, USA, 2nd ed.
Yin, R.K. (2014), *Case Study Research Design and Methods*, Thousand Oaks, CA: Sage Publications, Inc, 5th ed.
Zairi, M. (1996), 'Economic development and global competitiveness: why should Arab managers take note of total quality management', *The Fourth Arab Management Conference, 16-18 July*, University of Bradford, Bradford, UK.
Zhang, Q., Irfan, M., Khattak, M.A.O., Zhu, X. and Hassan, M. (2012), 'Lean Six Sigma: a literature review', *Interdisciplinary Journal of Contemporary Research in Business*, Vol. 3 No. 10, pp. 599–605.
Zhen, H. (2009), 'Learn something about six sigma program's maturity', *Quality Progress*, Vol. 42 No. 8, pp. 22–28.
Zinkgraf, A.S. and Snee, R.D. (1999), 'Institutionalizing six sigma in large corporations: a leadership roadmap', *Quality and Productivity Research Conference*, New York.
Zu, X., Fredendall, L.D. and Douglas, T.J. (2008), 'The evolving theory of quality management: The role of Six Sigma', *Journal of Operations Management*, Vol. 26 No. 5, pp. 630–650.
Zwetsloot, I.M. and Does, R.J.M.M. (2015), 'Quality Quandaries: Improving Revenue by Attracting More Clients Online', *Quality Engineering*, Vol. 27 No. 1, pp. 130–138.

Appendices

A. Literature Review

Table A.1: LSS specialist journals and the number of hits (papers) in each journal

	Journal name and database	Start date	Entries papers	Relevant papers	Country of Origins
1.	International Journal of Lean Six Sigma	2010	34	11	UK
2.	International Journal of Six Sigma & Competitive Advantages	2004	15	6	Switzerland
3.	International Journal of Productivity & Performance Management	2004	12	5	UK
4.	Quality Management Journal (ASQ)	1993	4	0	US
5.	Six Sigma Forum Magazine (ASQ)	2001	23	7	US
6.	Quality Progress (ASQ)	1995	41	1	US
7.	Quality Engineering (ASQ)	2004	20	14	US
8.	Journal for Quality & Participation (ASQ)	1987	1	0	US
9.	Journal of Quality & Technology (ASQ)	1969	0	0	US

Table A.2: Number of Lean, Six Sigma and LSS hits (papers) in academic journals

	Journal Name	Entries papers	Relevant papers
1.	International Journal of Production Research	4	1
2.	International Journal of Production Economics	0	0
3.	European Journal of Operational Research	0	0
4.	Journal of the Operational Research Society	1	1
5.	Production Planning and Control Journal	5	4
6.	International Journal of Operations and Production Management	1	0
7.	Manufacturing and Service Operations Management Journal	7	0
8.	International Journal of Management Science (OMEGA)	6	0
9.	Sloan Management Review (MIT)	7	0
10.	Management Science	1	0
11.	Harvard Business Review	7	1
12.	Production and Operations Management	1	0
13.	Journal of Operations Management	1	0
14.	Technovation	1	0
15.	Decision Sciences Journal	0	0
16.	International Journal of Quality and Reliability Management	12	7
17.	TQM Journal	13	1
18.	Journal of Manufacturing Technology Management	2	2
19.	Quality and Reliability Engineering International	3	1
20.	International Journal of Technology Management	2	2
21.	Manufacturing Engineer (IEEE Transactions)	3	1
22.	TQM and Business Excellence	9	0
23.	European Journal of Industrial Engineering	1	1
24.	Operations Research	0	0
25.	Mathematics of Operations Research	0	0
26.	Decision Analysis	0	0
27.	Manufacturing & Service Operations Management	0	0
28.	Interfaces	1	0
29.	Naval Research Logistics (star journal)	0	0
30.	Operations Research Letters	0	0
31.	IIE Transactions	4	0
32.	Annals of Operations Research	2	0
33.	Mathematical Programming	0	0
34.	Transportation Science	0	0

35.	Journal of the American Statistical Association	2	0
36.	Computers & Operations Research	1	0
37.	Decision Support Systems	1	0
38.	Academy of Management Journal	1	0
39.	Business Process Management Journal	2	0
40.	British Journal of Management	0	0
41.	California Management Review	0	0
42.	European Business Review	0	0
43.	IEEE Transactions on Engineering Management	0	0
44.	Journal of the Operational Research Society	1	1
45.	Journal of Business & Economic Statistics	0	0
46.	Journal of Business Venturing	0	0

Table A.3: LSS Critical Success Factors

CSFs	Explanation	References
Training and education	Training the team members and managers is very helpful in improving their skills (Chakravorty and Shah, 2012). However, some organisations do not prefer large-scale training and improvement programs as these need large investment and a long time for starting the deployment after the training. This large investment is due to training employees for unfamiliar methods for improvement (Snee, 2010).	Antony et al., 2003; Chakravorty and Shah, 2012; Timans et al., 2012; Jeyaraman et al., 2012; Vinodh et al., 2011; Pepper and Spedding, 2010; Hilton and Sohal, 2012; Pickrell et al., 2005; Akbulut-Bailey et al., 2012; Salah et al., 2010; Laureani and Antony, 2012; Snee and Hoerl, 2007; Breyfogle, 2008; Snee, 2010; Yi et al., 2012; Jeyaraman and Kee, 2010; Bisgaard and Does, 2009; Bakar et al., 2015.
Communication	Many practitioners have agreed that effective communication in the organisation is critical for LSS success. Effective communication helps LSS teams and leaders to be in touch and share results and any problems facing them during the implementation journey (Hardeman and Goethals, 2011).	Antony et al., 2003; Timans et al., 2012; Jeyaraman et al., 2012; Pepper and Spedding, 2010; Hilton and Sohal, 2012; Hardeman and Goethals, 2011; Akbulut-Bailey et al., 2012; Salah et al., 2010; Laureani and Antony, 2012; Arther and George, 2004; Snee and Hoerl, 2007; Snee, 2010; Jeyaraman and Kee, 2010.
Top management commitment and involvement	Snee (2010) argues that without top management commitment and support, LSS projects easily fail. The role of top management is to make sure that all required resources are available and that no obstacles will occur during the project implementation execution. Nonetheless, LSS success needs a corporate deployment champion to make sure that no obstacles can get in the way during the project execution.	Antony et al., 2003; Chakravorty and Shah, 2012; Timans et al., 2012; Jeyaraman et al., 2012; Vinodh et al., 2012; Vinodh et al., 2011; Pepper and Spedding, 2010; Hilton and Sohal, 2012; Salah et al., 2010; Laureani and Antony, 2012; Arther and George, 2004; Snee, 2010; Jeyaraman and Kee, 2010; Wijma et al., 2009; Bisgaard and Does, 2009; Douglas et al., 2015.
Organisational culture	Organisational culture is what determines which methodology is most appropriate for an organisation.	Timans et al., 2012; Vinodh et al., 2012; Vinodh et al., 2011; Hilton and Sohal, 2012; Pickrell et al., 2005; Laureani and Antony, 2012; Arther and George, 2004; Salah et al., 2010; Douglas et al., 2015; Ndaita et al., 2015.
Project selection and prioritisation	A system for project selection and prioritisation should be designed in each LSS company. This system should take into account the different types of projects (Timans et al., 2012) and choose the right people and the right tools for the project. The most appropriate project is the project with the most potential benefits to the bottom-line (Snee, 2010).	Timans et al., 2012; Pepper and Spedding, 2010; Salah et al., 2010; Laureani and Antony, 2012; Arther and George, 2004; Snee and Hoerl, 2007; Snee, 2010; Jeyaraman and Kee, 2010.

Availability of resources	In many cases, LSS projects fail due to lack of resources such as lack of financial resources, lack of physical resources, lack of technical resources, etc.	Antony et al., 2003; Pepper and Spedding, 2010; Hilton and Sohal, 2012; Laureani and Antony, 2012; Timans et al., 2012; Jeyaraman and Kee, 2010.
Linking LSS to customer	Customer focus is at the heart of LSS as stated by Corbett (2011). Customers should be the main focus in an organisation, and the voice of the customer should be linked to the LSS objectives and should be one of the criteria for selecting and prioritising projects (Antony, 2012).	Timans et al., 2012; Salah et al., 2010; Laureani and Antony, 2012; Corbett, 2011; Arther and George, 2004.
Organisational infrastructure	Snee (2010) defined the organisational infrastructure as the availability of all levels of experts in LSS such as GB, BB, MBB, champion and senior management leadership. The researcher argues that all employees should ideally be YBs.	Timans et al., 2012; Hilton and Sohal, 2012; Pickrell et al., 2005; Laureani and Antony, 2012; Snee, 2010; Douglas et al., 2015.
Linking LSS to HR reward system	It is essential that a link is made that enables the HR reward system to reward LSS members for their efforts and support for the implementation of successful LSS projects (Salah et al., 2010).	Laureani and Antony, 2012; Salah et al., 2010; Snee and Hoerl, 2007; Snee, 2010; Jeyaraman and Kee, 2010.
Supply chain focus	This factor is related to the relation between an organisation and suppliers (Timans et al., 2012). Author argues that long-term relationships with suppliers can improve productivity, quality and customer satisfaction.	Timans et al., 2012; Salah et al., 2010; Laureani and Antony, 2012; Arther and George, 2004.
Business vision and plan statement	The availability of an organisation's vision and future plan helps an LSS team to focus their work in the right direction, towards the organisation's goals (Corbett, 2011).	Timans et al., 2012; Hilton and Sohal, 2012; Akbulut-Bailey et al., 2012; Corbett, 2011.
Effective and efficient performance measurement and management system	One of the most critical factors, and often ignored, but without an effective measurement system, it is almost impossible to measure the size of a problem, the impact of an improvement, the quality of a product or service and the impact on customer satisfaction. Both efficiency and effectiveness are important. One is measuring things right first time and the other is measuring the right things.	Hilton and Sohal, 2012; Pepper and Spedding; Arther and George, 2004; Snee, 2010; Timans et al., 2012.
Choosing the most talented people	Snee (2010) argued that the success of LSS depends on entrusting LSS deployment effort to the most talented people in the organisation. It is a challenging task and not straightforward; however, skilled leadership can tackle this challenge easily.	Salah et al., 2010; Laureani and Antony, 2012; Corbett, 2011; Snee, 2010.
Visionary leadership	According to Laureani and Antony, identification of visionary leadership is one of the important factors for successful implementation of LSS. However, little has been written in literature in this area.	Laureani and Antony, 2012; Corbett, 2011; Arther and George, 2004; Snee, 2010; Ndaita et al., 2015.
Employee engagement and their active involvement throughout the LSS deployment	All previous examples only included permanent workers in the implementation teams. Chakravorty and Shah (2012) stated that workers' engagement and involvement in the deployment is critical for the success of	Chakravorty and Shah, 2012; Vinodh et al., 2012; Akbulut-Bailey et al., 2012.

	LSS in an organisation.	
Understanding and awareness of LSS	Carrying out LSS projects will help organisations to gain a better understanding of the mechanism of LSS implementation. It also helps to reduce the concern about failure. Training and education is another way to improve better understanding (Snee, 2010).	Timans et al., 2012; Laureani and Antony, 2012; Snee, 2010.
Linking LSS to business strategy	Linking project objectives to business strategy is significant and the link should be identified in every single project (Timans et al., 2012).	Timans et al., 2012; Laureani and Antony, 2012; Arther and George, 2004.
Project management skills	Many LSS projects have failed due to the lack of project management skills. This can lead to missing important deadlines and milestones (Hilton and Sohal, 2012). Poor project scope could lead to project failure. The project manager should have the skills to determine the resources required (how many people, what data need to be collected, etc.).	Timans et al., 2012; Hilton and Sohal, 2012; Laureani and Antony, 2012; Bisgaard and Does, 2009; Ndaita et al., 2015.
Organizational competency	This includes learning organisation, ability to work in teams and an appropriate infrastructure that allows individuals to be creative and innovative. It also includes the competency of the project leaders, BB, GB, workforce and deployment facilitator (Hilton and Sohal, 2012).	Hilton and Sohal, 2012; Kucner, 2009; Jeyaraman and Kee, 2010.
Personal LSS experience of top management	This factor is related to the level and year of experience of the LSS project leader as well as the number of successful projects that have been completed in LSS and not in quality management in general (Timans, 2012).	Timans et al., 2012; Hilton and Sohal, 2012.
Informal communication and open discussion	This kind of communication, e.g. during lunchtime, helps to discuss general issues and give team leaders important information about wastes such as breakdowns, setup time and material flow (Chakravorty and Shah, 2012).	Chakravorty and Shah, 2012; Hilton and Sohal, 2012.
Finding and understanding the problem correctly in the first place	It is a big challenge to find and identify the problem before taking any action to solve it. If the problem is not defined correctly, then the organisation is wasting time and money (Chakravorty and Shah, 2012). Author argues that using DMAIC methodology correctly can save an organization from this problem as the first stage of this method is to define the problem using specific and powerful tools and techniques such as process mapping, SIPOC, etc.	Chakravorty and Shah, 2012; Vinodh et al., 2012.
Systematic use of suggestion schemes, idea generation, etc.	To get more input from workers in different operations, and to encourage them to give their ideas about improvement (Chakravorty and Shah, 2012).	Chakravorty and Shah, 2012.
Clean and organized work area	Organised work areas can help the LSS team to reduce the time and effort needed to look for tools or equipment (Hardeman and Goethals, 2011). Author argues that this factor is a part of standard housekeeping, which is one of the objectives of Lean that can be achieved through 5S practice.	Hardeman and Goethals, 2011.

Patience to see the results	Implementing LSS takes time and needs patience, therefore the implementation process needs to be given the appropriate time to come up with the expected results (Akbulut-Bailey et al., 2012).	Akbulut-Bailey et al., 2012.
Developing the mindset of using LSS principles	One important factor is to encourage employees to think about LSS in all their daily tasks, and get into the habit of eliminating waste and caring about quality while they are working (Akbulut-Bailey et al., 2012).	Akbulut-Bailey et al., 2012.
Sustainability models for sustaining the results	Gaining benefits from LSS projects is only part of the story – it is important to put in place a plan for sustaining the results before the start of the project implementation phase.	Snee, 2010.
Project leader's soft skills	New CSF – any weakness in project leader attitude could be a barrier to the successful implementation of LSS (Timans et al., 2012).	Timans et al., 2012.

Table A.4: The benefits of successful implementation of LSS

Industry	Reasons behind implementing LSS	Tools and techniques	Benefits
Home furnishing (USA) (Chakravorty and Shah, 2012)	-To change the operation to show positive results -To improve employees' morale -To improve product quality and manufacturing operations	SIPOC, VSM, C&E analysis, SMED, DOE, ANOVA, Pareto analysis, Poka-yoke	-Improvement of manufacturing operation performance -Improvement of team members' skills -Improvement of production capacity -Reduction in cost, cycle time, customer returns and inventory -Reduction in variation and waste from operation
Aircraft manufacturing company (USA) (Akbulut-Bailey et al., 2012)	- To improve the competitive position in the market -To increase the bottom-line by reducing the cost of operations	C&E analysis, Kanban, Jidoka	-Sales went from \$30m to \$205m / year -Reduction in inventory, waste, production cost, labour time and cycle time -Significant improvement in quality -Increase in production, customer satisfaction and market share
Proprietary military products (worldwide) (Pickrell et al., 2005)	-To reduce production cost -To reduce cycle time, customer returns backlog, support labour and inventory -To increase production capacity	SIPOC, C&E analysis, DOE, SPC, process mapping, brainstorming	-50% overall reduction in total cost -53% reduction in cycle time -82% reduction in customer returns backlog -32% reduction in support labour required 52% increase in production capacity -50% reduction in inventory -Deeper understanding of production process
Compressor air-foil factory (USA) (Hardeman and Goethals, 2011)	-To improve the efficiency of the shimming process -To enhance the quality of the product	C&E analysis, FMEA	-94% reduction in product defects -Increased sigma value from 0.868 to 3.207 -Elimination of unnecessary tooling and work area cleaned up -Effective storage system has been created -Significant improvement in the process efficiency -Reduction in the amount of product scrapped
Small engineering company (UK) (Thomas et al., 2009)	-To examine the validity of a new LSS integrated approach that has been developed by the researchers in the study	5S, VSM, TPM, DOE, QFD, SPC	-A potential saving over the year of £29,000 -Increase in cell OEE from 34% to 55% -Increase in production by 31% per hour from 15 pph to 25 pph. This added 2,800 additional parts per annum -12% reduction in the use of energy per annum -Reduction in equipment downtime from 5% to 2% -Ability to compete in the market has increased

			significantly -Increased customer satisfaction -Company product portfolio shifted to a higher-value market sector -Increased awareness of statistical techniques for problem solving
PCB manufacturer (China) (Lee and Wei, 2009)	-To discover variation and waste causes in the ICT mould change process and reduce it -To reduce the number of irregular pin points on a pinboard	Process mapping, C&E analysis, ANOVA, FMEA, 5S, TPM	-Increase in production utilisation rate from 66.77% to 92.71% within 3 months -Increase in throughput by 22,500 PCBs per day -Significant reduction in fixture search time, an average of 4.73 to 1.53 min -Decrease in erroneous pins from 72% to 11.5% within 3 months, and to 1.8% within 6 months -Development of a plan for future maintenance and equipment replacement
Tyre manufacturing company (India) (Bhuiyan et al., 2006)	-To reduce defects occurring in production	VSM, 5S, C&E analysis, root-cause analysis	-Reduction in defective tyres in total monthly production from 22-25 % to 15% within the first month
Rotary switches manufacturing (India) (Vinodh et al., 2012)	-To reduce defects occurring in production and streamline process flow -To increase customer satisfaction - To reduce scrap and rework cost	Pareto chart, C&E analysis, VSM, control charts, DOE, Kanban, 5S, Poka-yoke	-10% reduction in product defects -10% reduction in defects in each stage of key performance metrics -7% increase in first-time yield (FTY) -Better customer satisfaction -Reduction in machine breakdown time -Increase in profit -More than 50% reduction in work in process (WIP) inventory -Identified 7 types of waste -Increased employee morale towards creative thinking
Touch panel manufacturing (Taiwan) (Chen and Lyu, 2009)	-To improve the quality of the touch panel -To increase customer satisfaction regarding product price and quality -To improve yield rate	VOC, C&E analysis, SIPOC, ANOVA, Pareto analysis, SPC, DOE, current state map	-Reduction in defects from 32.4% to less than 15% -Reduction in product cost and increase in customer satisfaction -Development in LSS members' experience and knowledge of advanced statistical training such as design of experiments (DOE) since the DOE is a key success factor during the improvement phase -The process capability analysis of the stamp process yielded a Cpk of 2.34 and Ppk of 2.25, implying the process has already reached a Six Sigma quality standard
Automobile accessories manufacturing (India) (Kumar et al., 2006)	-To reduce defects occurring in the finished product -To win customer loyalty -To enhance the bottom-line -To reduce work in process inventory -To reduce cost of scrap and rework	Current state map, 5S, TPM, VOC, Pareto analysis, brainstorming, DOE, control charts, FMEA	-Significant financial saving of $46,500 per year due to defect reduction -Reduction in machine downtime from 6% to 1% -Over $33,000 saving per year due to 25% reduction in process inventory -$20,000 may be saved due to the reduction in workplace accidents as a result of housekeeping procedures -Key performance metrics have improved significantly (e.g. defect per unit (DPU), process capability, first-time yield (FTY), etc.) -Increased overall equipment effectiveness (OEE) and thus the overall plant efficiency (OPE) -Reduction in customer complaints, machine setup

			time, workplace accidents -Total savings of around $140,000 per year
Automotive valve manufacturing (India) (Vinodh et al., 2011)	-To improve FTR -To reduce defects occurring in the finished product and increase customer satisfaction	SIPOC, brainstorming, VOC, current state map, 5S, VSM, Pareto chart, C&E analysis, control chart, DOE, Kanban	-Customer satisfaction has increased -The improvement of first-time right (FTR) percentage from 98.2% to 99% would save 28,000 valves per month from rejection -Significant savings have been achieved -Reduction in machine breakdown time, inventory, change over time (C/O) by 25%, and in manufacturing lead time by 18.53% -50% decrease in DPU -17.64% increase in OEE -Reduction in annual movement of materials from 2,040 miles to 1,300 miles; hence, the material movement cost has reduced from $187,298 to $103,886 per year
Industrial cleaning equipment manufacturing (USA) (Franchetti and Yanik, 2011)	-To reduce cost by 15%, reduce waste and protect revenue -To achieve competitive advantage in quality and market share -To increase manufacturing capacity by 10%	CTQ analysis, SIPOC, brainstorming, VSM, Pareto analysis, root-cause analysis, FMEA, Kanban	-$660,000 reduction in cost per year -50% reduction in work cells
Armaments products (USA) (Corbett, 2011)	-To gain financial benefits by reducing cost and cycle time	5S, TPM, VSM, process map, C&E analysis, XY matrix, FMEA, capability analysis, SPC, ANOVA, DOE, control charts, root-cause analysis	-Improvements of 91% in quality, 70% in cost, 67% in delivery, 84% in risk -$3bn cost benefit from 2001 to 2007 -Won Malcolm Baldrige National Quality Award (MBNQA)
Building products (New Zealand) (Corbett, 2011)	-To build niche market -To gain financial benefits by reducing cost and cycle time	5S, TPM, VSM, process map, C&E analysis, XY matrix, FMEA, capability analysis, SPC, ANOVA, DOE, control charts, root-cause analysis	-$28m annual saving from 2002 to 2007 -Won Business Excellence Award (BX)
Honeywell International Inc. (USA) Manufacturing different products from aerospace products to electronic materials (William and Willie, 2003)	-To reduce final product sale prices by 50% -To improve productivity capacity by double -To grow the business to $1m and $250 thousands in impact -To improve cash flow	Process mapping, C&E analysis, FMEA, SPC, 5S and mistake proofing	-$3b in financial benefits from 1995 to 2001 -$1.2b gains in 2002 as a result of waste reduction -Cycle time reduced from 12 to 10 days -Product travel distance reduced significantly from 300Km to 14Km - Reduction in manufacturing cost by 50%

Large valve remanufactu-ring (USA) (Kucner, 2009)	To improve quality, reduce cost and shorten cycle time in the carrier's design and manufacture	5S, VSM, kaizen, brainstorming, root-cause analysis	-Throughput of remanufacturing line nearly tripled -Average component lead time was reduced from 180 days to 40 days, overtime was eliminated, and cost and schedule goals were regularly achieved -Quality and communication improved significantly
Automotive electronic component assembly plant (Malaysia) (Yi et al., 2012)	-To reduce production cost - To reduce defects in production - To reduce losses ($300,000) from electronic component loss	C&E analysis, Pareto chart, brainstorming, 5S, VSM, Poka-yoke, SPC	-18% reduction in electronic component losses in the plant from $7,680 to $6400 within 16 weeks of the improvement phase -Significant reduction in production cost
Printing sample boards manufactur-ing (USA) (Roth and Franchetti, 2010)	-To meet the projected yearly demand of 200,000 boards (recently 143,400 boards/year) by reducing waste in the process and increasing production capacity through waste reduction -To increase clients' competitive advantage in the printing industry	Pareto chart, E-kanban system, SOP, check sheet	-Customer demand has been met by creating better processes and improved product cost -Labour cost minimized by establishing the optimal number of employees -Reduced the number of defects in the production process -Quality of finished goods has been improved
Intel's manufacturing R&D environment (USA) (Panat et al., 2014)	-To eliminate waste and improve current process -To reduce idle wait time by 40% -To improve the innovative environment.	Flow chart, SIPOC, control chart, current state map, process map, Pareto chart, FMEA	-Improve efficiency by 60% reduction in idle wait time -Increased stakeholder satisfaction -Reducing the NVA time by 11% -Reduced the variability in the business process - Significant cost savings for the company
Insurance and financial services (India) (Sarkar et al., 2013)	- To reduce cycle time in the claim settlement process	SIPOC, FMEA, histogram, process capability analysis, regression analysis, process map, flowchart, Pareto analysis, root-cause analysis	-Reduced cycle time which led to reduced operational cost -Increased customer satisfaction -Increased business reputation -Scope of new business generation
Recycling industry (USA) (Franchetti and Barnala, 2013)	- To improve the processes and increase capacity for a government operated material recovery facility	Flowchart, Pareto analysis, C&E analysis, check sheet, control chart, process capability analysis	-Reducing the non-value-added activities has resulted in: -Increased productivity by 7.3% for paper bales, 12.8 % for commingled bales and 1.6 % for old corrugated container (OCC) bales. -Over $65,000 annual savings for the facility -Improved employees' skills toward process improvement, using statistical tools to solve problems
Logistics centre- Taiwan (Lee et al., 2013)	-To increase the efficiency of the refund process of the logistics centre	CTQ, process map, C&E analysis, hypothesis testing, ANOVA, FMEA, VSM	-Eliminated non-value-added activities and redesigned the refund process -Reduced waiting time of credit voucher from 14 days to 14 min which led to increased customer satisfaction -Reduced error rate in the refund process to almost zero -Financial benefit of the project was about NT$1,200,000 in annual savings -Increased the company reputation

Local manufacturing company- USA (Franchetti, 2014)	-To reduce costs by nearly $243,000 per year (10%) and increase manufacturing capacity by 20% - To increase market share by increasing production -To create a practical roadmap	VSM, CTQ, SIPOC, Pareto analysis, root-cause analysis, FMEA, current state map, Spaghetti diagram	-38% increase in the company revenue - Expected saving of over $243,000/year due to cycle time reduction, labour cost reduction - Nearly 20% increase in manufacturing capacity
Call centre -UK (Laureani et al., 2010)	-To increase the first-call resolution ratio -To increase customer satisfaction and centre repetition	SIPOC, process map, hypothesis testing, Pareto analysis, brainstorming, control chart	-Further LSS projects were planned - Reduction in unresolved first-time calls from 11.82% to 8.45% -Reduction in the number of annual calls to 36,000 fewer calls which made a saving of $20,000 to the call centre
Construction Company -USA (Anderson and Kovach, 2014)	Reduce the average butt weld repair rate for the La Porte division to 2.75% in the next 6 months, resulting in estimated savings of $75,000-$100,000 per year -To keep projects on schedule, improve customer satisfaction, and generate a significant financial saving for the organization	Process map, SIPOC, C&E analysis, flowchart, histograms, Pareto charts, brainstorm, 5 Whys, FMEA	-An annual savings of $90,000 from direct labour costs - Substantial reduction in the weld repair rate
Higher Education Netherlands (Akkerhuis et al., 2015)	-To maintain market share -To align processes and carry over best practices. -To reduce operational costs -To increase student satisfaction	Flowcharts, VSM, 5S	-Increase in the number of enrolled students in the international programmes by 22% has generated an extra income of €150,000 -The standardization of administrative processes has resulted in a personnel reduction of four full-time equivalents - Job satisfaction of new employees is expected to improve, and the waste of productive hours of new employees is expected to be reduced
Healthcare Netherlands (Wijma et al., 2009)	-To improve service quality, especially nursing -To reduce operational coast and make savings to the bottom-line -To improve the nursing efficiency	SIPOC, CTQ, Pareto analysis, ANOVA, regression analysis, FMEA	-Cost reduction in nursing department by €147,000 -Financial saving of €100,000 from each department due to reduced labour cost and quality improvement - Time is available for professional development e.g. training, discussion, medical ethics, etc. -The job satisfaction for nurses has increased due to reorganising the work and eliminates the administration work
Healthcare Netherlands (Bisgaard and Does, 2009)	-To reduce the length of hospitalisation of patients -To improve quality and reduce cost at the same time	VSM, 5S, CTQ, flowchart, C&E analysis, dot plot, Pareto analysis, ANOVA, histogram, Scatterplot, t-test	-Reduction in the length of patients hospitalisation by 2.4 days - The expected annual saving is approximately $36,000. - The hospital can treat more patients with 72 more bed days available per year. - Quality has improved
Healthcare Netherlands (Schoonhoven et al., 2013)	-To shorten the throughput time of the billing process - To decrease average throughput time by at least 2 weeks, resulting in cost savings of 120,000 euros	Flowchart, CTQ, Gantt charts, Pareto analysis	-Financial benefits of €240,000 - Reduction in throughput times by one month -Expected reduction in throughput time by a further 55 days in the following year, potentially generating further cost savings of €150,000

Healthcare Netherlands Lokkerbol et al., 2012)	-To improve the process and reduce the time of handling documents relating to the unemployment benefit administration. -To save $250,000 as a result of personnel reduction	SIPOC, flowchart, CTQ, VSM	- The expected annual savings are approximately $325,000 per year - Reduction in waiting time of handling documents from 54 hours to approximately 31 hours
Healthcare Netherlands (Schoonhoven et al., 2011)	-To improve the quality of outpatient care -To be more efficient in resources allocation -To increase the revenue of the hospital	SIPOC, CTQ, VSM	-The expected growth rate of the number of new patients is 5% which leads to a $60,000 increase in annual revenue -Reduction in the admission times for new patients which allows 95% of patients to book an appointment within 10 days - The increase in the number of patients has resulted to $20,000 extra revenue
IT & business services company Netherlands Erdmann et al., 2010)	-To reduce the throughput and processing time -To reduce personnel costs in the company	SIPOC, CTQ, VSM	- The annual financial benefit is around $56,000 as a result of increased interest earnings and reduced operational costs -Reduction in the average number of mistakes by 90% from 2.5 mistakes to 0.2 per invoice - Increase in the process efficiency caused a reduction in the total throughput time from 32 days to 10 days
Consultancy company Netherlands (Zwetsloot & Does, 2015)	-To improve the sales of the company by increasing the number of customers by 15% through the company website -To increase the revenue by about $62,000	CTQ, control chart, Pareto analysis, regression analysis	- Increase in the company revenues of around $79,000 in the first year and around $102,000 in the second year - Increase in the number of website visitors by 123 extra visitors (23%) and 10% in the following years
Pharmaceutical company Netherlands Kuiper1et al., 2014)	-To increase the process capacity by increasing machines' effectiveness	Process map, Pareto analysis, CTQ, control chart, 5S	- The machines' effectiveness has increased by approximately 16% - The financial benefits have reached up to $2,268 million per year - New production levels have been secured at the company
Media and Entertainment Company Netherlands (Erdmann et al., 2013)	-To streamline the procurement process -To reduce the operational costs of the purchasing process	Pareto analysis, CTQ, control chart, VSM, brainstorm, C&E analysis, FMEA, ANOVA	- The procurement process time has decreased by 35% from 5.2 minutes to 3.4 minutes, which led to reduce the personnel cost of approximately $85,000 - The overall benefits from LSS project have reached $147,000
Healthcare Netherlands (Niemeijer et al., 2012)	-To achieve optimal and appropriate use of diagnostic tests -To reduce cost of services by 10% -To improve care processes and eliminate waste	CTQ, Pareto analysis, VSM, root-causes analysis, control chart	-The average cost of diagnostics per treatment decreased from $44 to $39 -The overall cost has decreased by 1.2% in three years despite 10% more treatments - Selective and timely approach of diagnostic tests resulted in average cost savings of 12.1% or $5 per patient. For the clinic, this represents $71,209 annual cost savings
Healthcare Netherlands (Kemper et al., 2009)	- To reduce the total costs in the process of ordering and maintaining infusion pumps by at least $27,000	SIPOC, CTQ, control chart	-The number of infusion pumps has reduced by 10%, and there is a potential reduction of almost 20% -This results in a yearly reduction of depreciation of about $21,000 and a potential of about $41,750 yearly

Financial services Portugal (Delgado et al., 2010)	-To examine the use of LSS by a financial services organization	FMEA, brainstorming, C&E analysis, VSM, QFD, VOC, VOE, DFLSS	- The operational costs have reduced - Products and process quality has improved - Efficiency has increased which leads to the increase of productivity
Hypothetical Company USA (Tatikonda, 2008)	-To identify root causes, streamline the billing process and reduce errors	Flowchart, histogram, Pareto analysis, C&E analysis, brainstorming, VSM	-Reduction in the billing process from 13 steps to 3 steps -Reduction in the cycle time to less than a day - Increase in the cycle efficiency from 0.5% to 10.4%
Medical College hospital India (Bhat et al., 2014)	-To improve the registration process in the Health Information Department	Normality test, Xbar-R chart, capability analysis, VSM, Multi-Vari chart, ANOVA, GEMBA, simulation, Pareto analysis, CTQ, SIPOC, flowchart, brainstorming, C&E analysis	-Reduction in the cycle time of the process from 3 to 1.5 minutes -Reduction in the standard deviation the SD from 61 seconds to 21.2 seconds -Reduction in patients' average waiting time by 94% -Reduction in queue length by 91%.
Service industry Ireland (Laureani and Antony, 2010)	-To reduce employees' voluntary turnover to an overall average of 25% across the organisation -To increase employee satisfaction, hence -To increase the return on investment of human capital	Process map, VSM, control chart, brainstorming, Kaizen	-Reduction in employees' turnover rate from an average of 35 to 25% -Cost savings of $1.3 million on an annual basis - Employee satisfaction rate has increased significantly
Tyre manufacturing organisation India (Gupta et al., 2012)	-To reduce defects in the process	Root-cause analysis, VSM, 5S, Kaizen, flowchart, C&E analysis	-Reduction in defective tyres from 25 to 15% of the total monthly production
Healthcare USA (Creasy and Ramey, 2013)	-To reduce patient wait time by 30%	Flowchart, SIPOC, CTQ, FDM, t-test	-Reduction in the average patient wait time from about 20 minutes to 6 minutes (70% reduction) -Reduction in the standard deviation from 18.9 minutes to 6.3 minutes (67% reduction)
Panel equipment manufacturer China (Wang and Chen, 2012)	-To reduce the cost of forecasting manufacturing -To eliminate defect and waste	SIPOC, brainstorming, VSM, FMEA, Pareto analysis, control chart, 5 Whys, C&E analysis, scatter plots, solution matrices, ANOVA	-Forecasting manufacturing costs were reduced from $29.8% in 2006 to $0.0125% in 2007, which led to cost saving of $4,710,262 -Increased the process capability from 0.78 and 0.64 to 1.62 and 1.49, respectively -Effective progress in the improvement of supportive activities as well as in the improvement of manufacturing processes
Higher Education Saudi Arabia (Svensson et al., 2015)	-To create a platform for improving business process quality across the administrative functions within the university	VSM, SPC, SIPOC, 5S, VOC, FMEA, CTQ, Gauge R&R, scatter plots, house of quality, Affinity diagram,	-Improvements in business processes and efficiency

	5 Whys, A3

Table A.5: Critical failure factors of LSS deployment

Factors	References
Lack of top management attitude, commitment and involvement	(Aboelmaged, 2011; Antony, Downey-Ennis, et al., 2007; Antony et al., 2012b; Arumugam et al., 2013; Bhasin, 2012a, 2012b; Chakravorty, 2009; Chiarini, 2011; Ho et al., 2008; Jeyaraman and Teo, 2010; Kumar et al., 2011; Kwak and Anbari, 2006; Martinez-Jurado and Moyano-Fuentes, 2012; Nwabueze, 2012; Pedersen and Huniche, 2011; Pepper and Spedding, 2010; Pinto et al., 2008; Scherrer-Rathje et al., 2009; Snee, 2010; Taner et al., 2007; Thomas et al., 2014; Worley and Doolen, 2006)
Lack of training and education	(Antony, 2008; Antony et al., 2005; Antony et al., 2012a; Antony, Downey-Ennis, et al., 2007; Bamber and Dale, 2000; Bhasin, 2012a; Chakravorty, 2009; Gurumurthy and Kodali, 2011; Hilton and Sohal, 2012; Kwak and Anbari, 2006; Lasa et al., 2009; Martinez-Jurado and Moyano-Fuentes, 2012; Panizzolo et al., 2012; Pedersen and Huniche, 2011; Pinto et al., 2008; Taner et al., 2007)
Poor project selection and prioritisation	(Aboelmaged, 2011, 2010; Antony et al., 2005; Antony, Antony, et al., 2007; Antony et al., 2012b; Chakravorty, 2009; Duarte et al., 2012; Kornfeld, B. and Kara, 2013; Kumar, Antony, et al., 2008; Kumar, Nowicki, et al., 2008; Kumar et al., 2007; Nonthaleerak and Hendry, 2008; Percin and Kahraman, 2010; Snee, 2010; Su and Chou, 2008; Taner et al., 2007)
Lack of resources (financial, technical, human, etc.)	(Aboelmaged, 2011; Antony, 2008; Antony et al., 2005; Antony et al., 2012b; Antony and Desai, 2009; Bhasin, 2012a; Kumar, Antony and Cho, 2009; Kumar, Antony and Douglas, 2009; Pedersen and Huniche, 2011; Pinto et al., 2008; Taner et al., 2007; Thomas et al., 2009)
Weak link between the CI projects and the strategic objectives of the organisation	(Antony et al., 2012b; Bhasin and Burcher, 2006; Chiarini, 2011; Hines et al., 2006; Kornfeld, B. and Kara, 2013; Kumar et al., 2011; Kumar, Antony and Cho, 2009; Kumar, Antony and Douglas, 2009; Pedersen and Huniche, 2011; Percin and Kahraman, 2010; Psychogios et al., 2012)
Resistance to culture change	(Antony et al., 2012b; Bhasin and Burcher, 2006; Bhasin, 2011, 2012a, 2012b; Black and Revere, 2006; Burcher et al., 2010; Chiarini, 2011; Harrison and Storey, 1996; Kwak and Anbari, 2006).
Poor communication	(Antony, Downey-Ennis, et al., 2007; Antony et al., 2012b; Bhasin, 2012a; Chakravorty, 2009; Hines et al., 2006; Pedersen and Huniche, 2011; Scherrer-Rathje et al., 2009; Worley and Doolen, 2006)
Lack of leadership skills and visionary and supportive leadership	(Antony, 2015; Antony et al., 2005; Antony, Downey-Ennis, et al., 2007; Antony et al., 2012b; Burcher et al., 2010; Chiarini, 2011; Hilton and Sohal, 2012; Kumar et al., 2011; McAdam and Lafferty, 2004; Suresh et al., 2012)
Lack of consideration of the human factors	(Antony, 2015; Bhasin and Burcher, 2006; Burcher et al., 2010; Chakravorty, 2009; Martinez-Jurado and Moyano-Fuentes, 2012; Psychogios et al., 2012; Ringen and Holtskog, 2011)
Lack of awareness of the benefits of Lean/Six Sigma	(Antony et al., 2012b; Martinez-Jurado and Moyano-Fuentes, 2012; Panizzolo et al., 2012; Psychogios et al., 2012; Scherrer-Rathje et al., 2009)
Wrong selection of Lean/Six Sigma tools	(AlAmin and Karim, 2013; Antony, 2006; Antony et al., 2005; Karim and Arif-Uz-Zaman, 2013; Nonthaleerak and Hendry, 2008; Nwabueze, 2012)
Narrow view of LSS as a set of tools,	(Aboelmaged, 2011; Antony et al., 2012b; Bhasin, 2012a, 2012b;

techniques and practices	Hilton and Sohal, 2012)
Lack of understanding of the different types of customers/VOC	(Antony et al., 2012b; Antony and Fergusson, 2004; Burcher et al., 2010; Hines et al., 2006; Nabhani and Shokri, 2009)
Lack of employee engagement and participation/lack of team autonomy	(Antony, 2015; Burcher et al., 2010; Jeyaraman and Teo, 2010; McAdam and Lafferty, 2004; Scherrer-Rathje et al., 2009)
Lack of process thinking and process ownership	(Aboelmaged, 2011; Antony et al., 2012b; Bhasin, 2012a, 2012b; Hilton and Sohal, 2012)
Poor organisation capabilities	(Chakravorty, 2009; Kumar, Antony and Douglas, 2009; Shah et al., 2008; Zhang et al., 2012)
High implementation cost	(Bhasin, 2012b; Chakravorty, 2009; Panizzolo et al., 2012; Percin and Kahraman, 2010)
Lack of experience in Lean/Six Sigma project implementation	(Gurumurthy and Kodali, 2011; Jeyaraman and Teo, 2010; Panizzolo et al., 2012; Pedersen and Huniche, 2011)
Lack of awareness of the need for Lean/Six Sigma	(Antony et al., 2012a; Gurumurthy and Kodali, 2011; Pamfilie et al., 2012; Psychogios et al., 2012)
Ineffective project management	(Jeyaraman and Teo, 2010; Kwak and Anbari, 2006; McAdam and Lafferty, 2004)
Poor selection of candidates for belts training	(Hilton and Sohal, 2012; Kumar, Antony and Cho, 2009; Snee, 2010)
Lack of clear vision and a future plan	(Bhasin, 2012a; Jeyaraman and Teo, 2010; Kwak and Anbari, 2006)
Lack of an effective model or roadmap to guide the implementation	(Chakravorty, 2009; Kumar et al., 2011)(Pepper and Spedding, 2010)
Poor execution	(Chakravorty, 2009; Nwabueze, 2012; Pinto et al., 2008)
Threat of redundancy	(Bamber and Dale, 2000; Gurumurthy and Kodali, 2011; Martinez-Jurado and Moyano-Fuentes, 2012)
Time consuming	(Panizzolo et al., 2012; Percin and Kahraman, 2010)
Lack of estimation of implementation cost	(Aboelmaged, 2011; Kumar, Nowicki, et al., 2008)
Weak infrastructure	(Arumugam et al., 2013; Snee, 2010)
Replicating another organisation's Lean/Six Sigma strategy	(AlAmin and Karim, 2013; Antony et al., 2012b; Bhasin, 2012a)
Lack of a performance measurement system	(Karim and Arif-Uz-Zaman, 2013; Kumar et al., 2007)
Lack of understanding of how to get started	(Kumar et al., 2011; Kumar, Antony and Douglas, 2009)
Lack of application of statistical theory	(Thomas et al., 2009)
Weak linking to suppliers	(Bamber and Dale, 2000)
Misalignment between the project aim, the main goals of the company and the customer demand	(Ho et al., 2008)

B. Survey

B.1. Survey Invitation Letter

Dear Sir/ Madam

I am approaching you with the objective of collecting some general information about you and your organisation in support of my Doctoral study in Lean Six Sigma. My Doctoral study aims to critically assess the level of implementation of Lean Six Sigma within Saudi Arabian organisations, and to compare it with levels of Lean Six Sigma implementation in the Western countries that have appeared in literature, such as United State, United Kingdom and others.
After my data collection and analysis is complete, it will be used to develop a Lean Six Sigma Maturity Model for Saudi Arabian organizations. Then the Model will be modified according to the results of interviews with experts and consultants in the field of Lean Six Sigma, and a copy of the final model will be sent to each company that contributed to this research. This survey is the first stage and it will be followed with a second stage survey in couple of weeks.

The results from the survey will be used for the research purpose only and no attempt will be made to identify any individual in the organisation. All responses will be treated with the utmost confidence and no single set of responses will be readily identifiable. At any time and for any reason, you can refuse to answer a question or stop filling out the questionnaire.

Your assistance and time taken to complete this questionnaire is greatly appreciated

Yours faithfully,

Saja Albliwi

PhD Candidate
School of Management and Languages
Heriot-Watt University
Edinburgh, Scotland

B.2. Questionnaire

Q1. Name of the organisation

Q2. Start-up year

Q3. How many employees does your organisation have?
- ❍ Less than 500
- ❍ 500 to 1,000
- ❍ 1,100 to 5,000
- ❍ 5,100 to 10,000
- ❍ More than 10,000
- ❍ Don't know

Q4. What is your organisation's annual turnover ($)?
- ❍ Less than 1 million
- ❍ 1m- 5m
- ❍ 5m- 15m
- ❍ 15m - 25m
- ❍ 25m- 50m
- ❍ Over 50m
- ❍ Other ____________________

Q5. What is your current position within the organisation? (check all that apply)
- ❑ CEO, Director, General Manager
- ❑ Departmental Head
- ❑ Quality Manager
- ❑ Assistant Manager
- ❑ Team Leader
- ❑ Supervisor
- ❑ Staff
- ❑ Yellow Belt
- ❑ Green Belt
- ❑ Black Belt
- ❑ Master Black Belt
- ❑ Lean or Six Sigma or Lean Six Sigma Champion
- ❑ Other ____________________

Q6. Which department do you work for?

Q7. How long your organisation has been deploying Lean/Six Sigma/Lean Six Sigma? (check all that apply)
- ❑ Lean ____________________
- ❑ Six Sigma ____________________
- ❑ Lean Six Sigma ____________________
- ❑ Don't Know

Q8. What proportion of employees has been trained as Yellow Belts?
- ❍ Less than 15%
- ❍ 16% to 30%
- ❍ 31% to 45%
- ❍ 46% to 60%
- ❍ Over 60%
- ❍ Don't Know

Q9. What proportion of employees has been trained as Green Belts?
❍ Less than 15%
❍ 16% to 30%
❍ 31% to 45%
❍ 46% to 60%
❍ Over 60%
❍ Don't Know

Q10. What is the ratio of the number of Black Belts to the total number of employees?
❍ 1:50 (this means for every 50 employees in the organisation you should have 1 Black Belt)
❍ 1:100 (this means for every 100 employees in the organisation you should have 1 Black Belt)
❍ 1:200 (this means for every 200 employees in the organisation you should have 1 Black Belt)
❍ 1:300 (this means for every 300 employees in the organisation you should have 1 Black Belt)
❍ None, Please specify ____________________

Q11. How many Master Black Belts are working in your organisation?
❍ None
❍ 1 to 5
❍ 6 to 10
❍ 11 to 15
❍ More than 15
❍ Don't know

Q12. How many Lean or Six Sigma or Lean Six Sigma Champions are working in your organisation?
❍ None
❍ 1 to 5
❍ 6 to 10
❍ 11 to 15
❍ More than 15
❍ Don't know

Q13. What is your level of awareness about Lean or Six Sigma?

	Not aware	Less aware	Somewhat aware	More aware	Fully aware
Level of awareness	❍	❍	❍	❍	❍

Q14. What is your organisational level of awareness about Lean or Six Sigma?

	Not aware	Less aware	Somewhat aware	More aware	Fully aware
Level of awareness	❍	❍	❍	❍	❍

Q15. Is there a quality department in your organisation?
❍ Yes
❍ No
❍ Don't Know

Q16. Which of the following continuous improvement methodologies have been used by your organisation at some time? (check all that apply)

- ❑ Kaizen
- ❑ Lean
- ❑ Six Sigma
- ❑ Total Quality Management (TQM)
- ❑ None
- ❑ Other ____________________

Q17. Which other business process improvement (continuous or breakthrough) methodologies have been used by your organisation at some time? (check all that apply)

- ❑ Business Process Management (BPM)
- ❑ Business Process Re-engineering (BPR)
- ❑ Theory of Constraints (TOC)
- ❑ None
- ❑ Other ____________________

Q18. Which Quality system or environmental management system has been used in your organisation? (check all that apply)

- ❑ ISO 9001
- ❑ ISO 14001
- ❑ ISO 13053 (Six Sigma)
- ❑ None
- ❑ Other ____________________

Q19. Which of the following awards are applied to your organisation?

- ❍ King Abdulaziz Quality Award
- ❍ European Foundation for Quality Management (EFQM) Excellence Model
- ❍ Malcolm Baldrige National Quality Award (MBNQA)
- ❍ Deming Prize
- ❍ None
- ❍ Other ____________________

Q20. Which of the following methodologies do you use for problem solving? (check all that apply)

- ❑ DMAIC (Define, Measure, Analyse, Improve, Control)
- ❑ PDCA (Plan-Do-Check-Act)
- ❑ DMADOV (Define, Measure, Analyze, Design, Optimize, Verify) Design for Six Sigma
- ❑ IDOV (Identify, Design, Optimize, Validate) Design for Six Sigma
- ❑ Other ____________________

Q21. In which areas have you seen the most impact from the used initiatives in Question 19? (check all that apply)

- ❑ Customer Service
- ❑ Administrative Process
- ❑ Production Process
- ❑ Financial Process
- ❑ Supply Chain
- ❑ Information System
- ❑ Inventory Process
- ❑ Other ____________________

Q22. What is the ratio of investment to benefits from Lean or Six Sigma or Lean Six Sigma projects?
- ❍ 1:3 to 1:5 (this means for every $100 you should have $300 to $500 on return on investment)
- ❍ 1:6 to 1:8 (this means for every $100 you should have $600 to $800 on return on investment)
- ❍ 1:9 to 1:10 (this means for every $100 you should have $900 to $1000 on return on investment)
- ❍ Over 1:10 (this means for every $100 you should have over $1000 on return on investment)
- ❍ Don't Know

Q23. How have you learned about quality improvement methods, tools and techniques?
- ❑ In-house training
- ❑ Company sponsored training in organisations or institutes
- ❑ Conferences
- ❑ Internet
- ❑ Distance learning
- ❑ Self-education, book or research articles
- ❑ Other ____________________

Q24. What are the motivational factors for implementing Lean/Six Sigma/Lean Six Sigma? (check all that apply)
- ❑ To improve employees' morale
- ❑ To improve product and process quality
- ❑ To change the competitive position in the market
- ❑ To increase the bottom-line
- ❑ To reduce cost of poor quality
- ❑ To increase production capacity by reducing machine breakdown time
- ❑ To improve process efficiency and effectiveness
- ❑ To understand and evaluate causes of variation and waste in the process
- ❑ To enhance business sustainability
- ❑ To reduce defects in all business process
- ❑ To increase customer focus
- ❑ To improve process yield rate
- ❑ To reduce time (cycle time, lead time, etc.)
- ❑ Others ____________________

Q25. What are the benefits gained from implementing Lean/Six Sigma/Lean Six Sigma in your organisation? (check all that apply)
- ❑ Increase profits and financial savings
- ❑ Increase customer satisfaction
- ❑ Reduce cost of Quality (defects, scrap, rework, repair, etc.)
- ❑ Reduce cycle time
- ❑ Reduce inventory
- ❑ Improve process/products quality
- ❑ Increase production capacity
- ❑ Increase market share
- ❑ Reduce labour time
- ❑ Reduce waste in the process
- ❑ Reduce overtime
- ❑ Others ____________________

Q26. Approximately what is the total investment (in US dollar $) your organisation has made in the initiative to date? (Note: investment includes training, consultants, software, and other resources) (check all that apply)
- ❑ None
- ❑ Lean ____________________
- ❑ Six Sigma ____________________
- ❑ Lean Six Sigma ____________________

- ❑ Don't Know

Q27. What is the return on investment (in US Dollar $) from Lean/Six Sigma/Lean Six Sigma to date?

- ❍ None
- ❍ Lean ____________________
- ❍ Six Sigma ____________________
- ❍ Lean Six Sigma ____________________
- ❍ Don't Know

Q28. How many Lean/Six Sigma/Lean Six Sigma projects have completed successfully in your organisation? (check all that apply)

- ❑ None
- ❑ Lean ____________________
- ❑ Six Sigma ____________________
- ❑ Lean Six Sigma ____________________
- ❑ Don't Know

Q29. How many Lean/Six Sigma/ Lean Six Sigma projects have failed in your organisation? (check all that apply)

- ❑ None
- ❑ Lean ____________________
- ❑ Six Sigma ____________________
- ❑ Lean Six Sigma ____________________
- ❑ Don't Know

Q30. What are the reasons for the failure of projects? (check all that apply)

- ❑ Lack of top management attitude, commitment and involvement
- ❑ Lack of training and education
- ❑ Poor project selection and prioritisation
- ❑ Lack of resources (financial, technical, human, etc.)
- ❑ Resistance of culture change
- ❑ Poor communication
- ❑ Lack of leadership skills and visionary and supportive leadership
- ❑ Lack of consideration of the human factors
- ❑ Lack of awareness of the benefits of Lean/Six Sigma
- ❑ Lack of experience in Lean/Six Sigma project implementation
- ❑ Poor selection of candidates for belts training
- ❑ Lack of an effective model or roadmap to guide the implementation
- ❑ Time consuming
- ❑ Weak infrastructure
- ❑ Replicating another organisation's Lean/Six Sigma strategy
- ❑ Lack of understanding of how to get started
- ❑ Others ____________________

Q31. What are the factors (Critical Success Factors) that lead to the success of Lean/ Six Sigma in your organisation? (check all that apply)

- ❑ Training and education
- ❑ Communication
- ❑ Top management commitment and involvement
- ❑ Organizational culture/ culture change
- ❑ Project selection and prioritisation
- ❑ Availability of resources
- ❑ Linking LSS to customer
- ❑ Organizational infrastructure
- ❑ Linking LSS to human resources (HR) reward system

- ❑ Choosing the most talented people
- ❑ Visionary leadership
- ❑ Understanding and awareness of LSS
- ❑ Linking LSS to business strategy
- ❑ Project management skills
- ❑ Personal LSS experience of top management
- ❑ Informal communication and open discussion
- ❑ Others ____________________

Q32. What are the most common challenges/ inhibitors of implementing Lean/Six Sigma/Lean Six Sigma in your organisation? (check all that apply)

- ❑ Difficulties in teaching statistical methods to some of the team members
- ❑ Time-consuming
- ❑ Internal resistance
- ❑ Unavailability of resources
- ❑ Changing business focus
- ❑ Lack of leadership
- ❑ Poor selection of projects
- ❑ Lack of tangible results
- ❑ Lack of training or coaching
- ❑ Poor employee relationships
- ❑ National regulations
- ❑ Employee attitude towards a new business strategy
- ❑ Convincing top management
- ❑ Lack of awareness about LSS benefits to the business
- ❑ Poor organisational infrastructure
- ❑ Others ____________________

Q33. What are the methodology/tools/techniques you use in Lean/Six Sigma/Lean Six Sigma projects? (check all that apply)

- ❑ DMAIC (define, measure, analyse, improve, control)
- ❑ SIPOC (suppliers, inputs, process, outputs, customers)
- ❑ Value Stream Mapping (VSM)
- ❑ Poke-Yoke
- ❑ Process mapping
- ❑ Brainstorming
- ❑ Root-cause analysis
- ❑ Kanban system
- ❑ Kaizen event
- ❑ 5S method (Sort, Straighten, Shine, Standardize and Self-discipline)
- ❑ Pareto analysis
- ❑ Control charts
- ❑ CTQ analysis (Critical to Quality)
- ❑ Process capability analysis
- ❑ Single-Minute Exchange of Die (SMED)
- ❑ Quality Function Deployment (QFD)
- ❑ Failure Mode and Effect Analysis (FMEA)
- ❑ Analysis of Variance (ANOVA)
- ❑ Measurement System Analysis (MSA)
- ❑ Kano Model
- ❑ Design of Experiments (DOE)
- ❑ Statistical Process Control (SPC)
- ❑ Taguchi method
- ❑ Spaghetti diagram
- ❑ Just in Time (JIT)

- ❑ Regression analysis
- ❑ Hypothesis testing
- ❑ Others ____________________

Q34. Does your organisation encourage employee to learn from their mistakes/failure projects?

	Definitely not	Probably not	Maybe	Probably yes	Definitely yes
Learning from mistakes/ failure projects	❍	❍	❍	❍	❍

Q35. How does the organisational culture impact the Lean/Six Sigma/Lean Six Sigma deployment?

	Strongly Negative	Somewhat Negative	No Impact	Somewhat Positive	Strongly Positive
Impact of Culture	❍	❍	❍	❍	❍

Q36. Please give more details for the impact of the culture in Lean/Six Sigma/ Lean Six Sigma

Contact Details: (it is very important to give your details) Please provide the following demographic information, for classification purposes only.

- ❑ Your Name and Title ____________________
- ❑ Organisation Name ____________________
- ❑ Nationality ____________________
- ❑ City ____________________
- ❑ Email ____________________
- ❑ Contact Number ____________________

C. Case Study

C.1. Case Study Protocol

1. Introduction to the case study and purpose of protocol

The aim of this research is to assess the current level of Lean Six Sigma adoption in Saudi Arabian organisations and to develop a maturity model for Lean Six Sigma that can help Saudi Arabian organisations to assess their level of Lean Six Sigma maturity. To fulfil this aim, and to answer the research questions presented in chapter 1, survey and case study research methods were chosen for this work. The survey was carried out with the intention to guide the direction of the case study. The case studies, on the other hand, collected in-depth data from the participating organisations. The latter were selected and filtered on the basis on having implemented Lean and/or Six Sigma for at least one year.

This protocol was written to homogenise the data collation process from a multiple case study approach; thus increasing the reliability and validity of conclusions derived from the case study.

1.1. Role of the protocol in guiding the case study

The case study protocol represents an agenda for the case study requirements and it is the basis for data collection and analysis. Preparing the protocol helped anticipate difficulties and avoid errors related to reporting the case study, identifying the audience, recognising the units of analysis, etcetera. This protocol also takes into consideration an interview best practice guide—presented in the next section of this appendix detailing the questions asked to the interviewees. Furthermore, a letter of introduction to the research aim, the methodology and schedule for data collection was sent to all interviewees in the targeted organisations (see appendix C.3).

1.2 Case study questions

To answer the research questions accurately, a set of case study questions and sub-questions were developed. These helped investigate the current situation of Lean and/or Six Sigma implementation including the advantages and disadvantages of the methodology, critical success factors and challenges, training and education, belt system, leadership, etc. Other questions determined other influencers like motivating factors, organisational learning and the effect of organisational culture on Lean and/or Six Sigma implementation.

The case study questions were derived from an in-depth systematic literature review which was presented in chapter 2 of this thesis. Complementary studies in Lean Six Sigma and Maturity Models were developed to highlight the knowledge gap in the literature and to develop the research questions for this doctoral research (see publications and conferences papers in page iv). In addition, some of the case study questions were developed from operations management theories like organisational learning and the theory of motivation. These were found to be the most relevant theories to Saudi Arabian organisations according to the findings reported in chapter 2.

The questions asked to the participants were dependent on the interviewees' position in their organisation. That is, some questions were prepared for CEOs and senior managers; other questions for LSS Champions, Master Black Belts/Black Belts and Green Belts. There were also questions specific to quality managers/process managers and financial managers. In all cases it was indispensable that the interviewees had at least top-level knowledge about Lean and/or Six Sigma methodologies in order to collect data relevant to the research questions.

2.Data collection process

The selected data collection technique for this case study was semi-structured interviews. The data was gathered through a series of interview questions prepared ahead of the interviews. The data was collected using a recording device (iPhone® and Sony® voice recorder) to store the data and handwritten notes were taken. The data was then transcribed and transferred to NVivo® for further qualitative data analysis.

The data collection method envisioned complies with the rules and recommendations of the Heriot-Watt University for ethical behaviour as well as the guidelines for protecting human subjects that participate in research. All forms have been duly submitted as per the requirements of the University.

2.1. List of participating organisations, including contact people

This multiple-case study was carried out in Saudi Arabia and it comprised five large organisations. The selected participants included: two public organisations and three private organisations; all in diverse locations within the kingdom—West, Middle and East. These were:

Organisation A - Contacted Person: Mr. Mohammed Ajaz
Organisation B - Contacted Person: Mr. Mohammed Alsubaie
Organisation C - Contacted Person: Dr. Ahmed Alkuwiti
Organisation D - Contacted Person: Mr. Abdullah Almutairi
Organisation E - Contacted Person: Mr. Bader Alabdullatif

2.2. Data collection schedule

The data was collected by visiting each organisation and spending circa 3 weeks interviewing relevant participants. All interviews were scheduled in advance catering for the availability of the interviewees. The interviews took place in the first quarter of 2015 stretching throughout 3 months. Each interview lasted approximately 60 to 90 minutes depending on the position and experience of the interviewee. However, there was room for a follow up interview to investigate further issues where appropriate.

The schedule allowed for time between interviews to reflect upon the findings, optimise the questionnaire if necessary and gather initial impressions that could influence the next interview. All sessions were confirmed prior to the date scheduled to confirm the availability of the interviewee. The interviews were divided into 3 phases:

- Phase 1: Introduction – To provide context regarding the research aim and objectives, highlight practical implications of the research, and explain how the data from interviews would be used.
- Phase 2: Background interview – To gather information about the interviewee, for instance: their background, education and training, current role and responsibilities, etcetera.
- Phase 3: Detailed interview – In-depth interview following the questionnaire developed for the case study. The order of the questions varied due to the nature of the conversations that arose during the semi-structure interviews. Questions specific to the participants of each management level were included to gather relevant information tied to their qualifications and experience in LSS deployment.

Participants from diverse levels of management responsibility within the organisation were selected to ensure that range of opinions and levels of involvement in the implementation of Lean and/or Six Sigma were part of the sample. This helped substantiate the validity of the conclusions derived from the research and ultimately answer the proposed research questions. Hence, the targeted interviewees were:

- CEOs/Senior managers: who understand the need for quality methodologies in their organisations and their strategies for the future, as well as the benchmark organisations, if any had been identified. Managers were most likely to be asked about the motivation for Lean and/or Six Sigma deployment and the way they support the initiative as well as the communication with their LSS team.

- Quality managers/Process managers: who have background about previous quality practices in the organisation and the reasons for implementing Lean and/or Six Sigma. This group would offer important information about the quality history in the organisation and the reasons for shifting from previous continuous improvement initiatives (if there were any) to Lean and/or Six Sigma.
- Financial managers/finance controller/financial team: who have experience about the investment in Lean/Six Sigma training and the financial benefits derived from the implementation. The targeted interviewees would have experience and a rich background on the financial issues related to Lean and/or Six Sigma and previous quality practices in the organisation. This would help expose details about the investment on continuous improvement practices, particularly Lean and/or Six Sigma.
- Lean/Six Sigma project champion: who manages Lean/Six Sigma projects and has rich information about previous Lean/Six Sigma projects in the organisation. At least one champion was interviewed in each organisation to collect data about the selection, prioritisation, motivation and benefits/pitfalls of the Lean and/or Six Sigma projects undertaken. The interviews also served to determine the need for a Lean Six Sigma maturity model tailored to Saudi Arabian organisations.
- Master Black Belts/Black Belts: who, in the past, have received training to become a BB and now train people in the organisation for YB, GB and BB, lead Lean and/or Six Sigma projects and the associated challenges, and currently deliver benefits to the organisation. Interviewing MBB and BB was critical to the process of understanding the current situation of Lean Six Sigma in their organisations and the development of the maturity model for LSS. This included gathering information about training, projects, challenges, leadership, management support, savings, etcetera.
- Green Belts: who were part of Lean and/or Six Sigma projects and had experience about training, challenges and impediments affecting Lean and/or Six Sigma projects; and who had a deeper understanding of issues related to management support, communication, project execution, and similar.

Interviewing employees with different levels of experience and management guaranteed data triangulation which is recommended in literature to increase the validity of the analysis and reduce bias and subjectivity.

2.3. Preparation prior to site visits

The knowledge and understanding of the background of the organisations that were interviewed had significant importance to understand the information gathered during the interviews. In addition to the information from the surveys, more technical information—key products and services, key customers, vision, mission, departments, structure—was gathered from websites, financial/operational/technical reports, and internal publications. The quality and quantity of the information available varied between organisations. While for some organisations relevant information was available online, for the other organisations there was little to be found.

3.Case study questions

The process of determining the case study questions is a critical component of the protocol and it is considered by many authors as the case study instrument or the heart of the protocol (Yin, 2003a, 2014). It reflects the main issues to be investigated and serves as a reminder of the information that needs to be collected from the interviews.

It was essential that the questions were related to the research aim and that they offered sufficient information to answer the research questions.

3.1. What is the current status of LSS implementation in Saudi Arabian organisations? (Themes)

a. Awareness, Infrastructure and Training for LSS
b. Methodologies, Tools and Techniques of LSS
c. Benefits Generated from LSS and the Impact of LSS on Business Functions
d. Critical Success Factors (CSFs) for LSS
e. Challenges for LSS Implementation
f. Impact of Organisational Culture and Leadership on LSS
g. Successful and Failed LSS Projects and Project Selection
h. Role of IT and HR in LSS

3.2. What are the motivating factors for Lean and/or Six Sigma implementation in Saudi Arabia?

a. Reasons for implementing Lean and/or Six Sigma
b. Employee motivation to be involved in Lean and/or Six Sigma training and projects

3.3. How can the maturity level of Lean Six Sigma in Saudi Arabian organisations be effectively assessed?

a. Models used to assess Lean and/or Six Sigma maturity level so far
b. Plans to develop a model or find suitable one to assess maturity level
c. Important ingredients for Lean Six Sigma maturity model
d. Important functions of the model

3.4. To what extent can Saudi Arabian organisations participating in the case study be considered as learning organisations in the context of Lean Six Sigma?

a. The role of the organisation in supporting organisational learning
b. Learning from mistakes and failed projects
c. Learning from other organisations
d. Sharing thoughts and opinions

4.Outline of case study report and analysis

The case study report is the detailed documentation of each case individually after finishing the data collection process. There are no clear agreed outlines to report a case study; thus, for this piece of work best practices from diverse academic sources were adopted.
In term of data analysis, there are plentiful ways of analysing the same data depending on the purpose of the research. For the purpose of this research, within-case analysis and cross-case analysis methods were selected since these are appropriate for multiple case study analysis.

4.1. Unit of analysis

In the case studies conducted as part of this research, two units of analysis were employed: the organisation and the themes identified from the review of Lean Six Sigma literature. The data source was the individuals who were interviewed.

4.2. Within-case analysis

Within-case analysis was used to analyse the data collected from each organisation. The results of the analysis were shaped as an overview of the organisation followed by the key findings in term of LSS current situation, motivating factors, organisational learning and maturity level.

4.3. Cross-case analysis

Using the cross-case analysis technique it was possible to identify the similarities and differences leading to common patterns across cases. It also facilitated the comparison and contrast of the key findings among cases.

4.4. Case study report

This section of the protocol is a guide for the case study report which includes outline, data formatting, use and presentation of other documentation and biographical information.

It is good practice to write the case study report after completing each interview to ensure that the data is not lost, misinterpreted or influenced by subsequent interviews.

It is necessary to determine the audience of the case study report before redacting it. For this research the targeted audience includes the community of academics, researchers, postgraduates, practitioners in the field of continuous improvement in particularly Lean and/or Six Sigma including the five organisations that participated in the study, and the sponsor of the study.

The case study reports in this research facilitated the cross-case analysis to find commonalities between cases whilst allowing for familiarity with each case as a stand-alone entity (Eisenhardt, 1989a). In this case, the reports are structured as follows:

1- Introduction
2- Overview of the organisation (brief history and organisation structure)
3- Quality practices
4- Lean and/or Six Sigma deployment
5- Motivating factors
6- Organisational learning
7- Lean and/or Six Sigma Maturity
8- Conclusion

This case study protocol has adapted from Yin, (2003a, 2003b) Yin (2014), Eisenhardt (1989a), Easterby-Smith et al., (2012), Saunders et al., (2009), and Brereton et al., (2008).

C.2. Semi-Structured Interview Questions

This section presents the proposed interview questions, which cover the following aspects:

1. Background information about the interviewees.
2. History of quality practices in the organisation.
3. The current status of Lean Six Sigma (LSS) implementation in the organisation.
4. Measuring LSS success in the organisation (financial, morale, employee engagement and ownership, leading to key findings from Saudi Arabian organisations).
5. Motivation for LSS implementation.
6. Organisational learning.
7. Maturity model for LSS.

The following interview questions have been classified according to the four research questions:

- RQ1 What is the current level of adaption of Lean Six Sigma in Saudi Arabian organisations?
- RQ2 What are the motivational factors for Lean Six Sigma deployment in Saudi Arabian organisations?
- RQ3 How can the maturity level of LSS in Saudi Arabian organisations be effectively assessed?
- RQ4 To what extent can Saudi Arabian organisations participating in the case study be considered as learning organisations in the context of Lean Six Sigma?

To answer research question 1, what is the current level of adaption of Lean Six Sigma in Saudi Arabian organisations? The following queries will be made:

1. CEOs / Senior Managers

I. Background information

a. What is your level of education?
b. How did you learn about LSS?
    - Have you had training? How many hours?
    - Are you aware of successful or failed projects in your organisation?
    - Do you regularly attend project presentations and understand how they work?
    - Who is executing the projects?
c. What are your roles and responsibilities within the LSS initiative in your business?
d. What sort of continuous improvement (CI) programme have you used in the past? Why did you move onto LSS?

II. Lean Six Sigma information

a. What is the definition of LSS from your perspective?
b. How did you get started on the LSS journey?
c. Do you participate in setting the corporate goals that will shape the LSS priorities?
d. Do you consider LSS as a top business priority and strategically linked to business goals?
e. Do you monitor and guide the use of LSS resources?
f. How many business functions are there in your organisation? How many of them are using LSS?

g. What were the criteria for choosing that specific area of the business for implementation? Was it piecemeal or whole?
h. Do you use a top-down or bottom-up approach for LSS implementation?
i. Is CI recognised as part of the culture in your organisation? How?
j. As a leader, do you recognise and appreciate the efforts and success of individuals and teams? How?
k. Do you think your organisation will continue the journey toward LSS? Why?
l. How do you manage and sustain LSS in the business?
m. How does organisational culture / country culture influence LSS implementation?
n. Do you think the organisational culture in Saudi Arabia is in favour of LSS? Does it support it?
o. Do you use any models for sustainability?

2. <u>Quality Managers / Process Managers / Process Owners</u>

I. Background information

a. What is your level of knowledge regarding quality and CI?
b. What is your past experience regarding quality and CI?
c. What are your roles and responsibilities within LSS initiative in the business?
d. What specific quality improvement initiatives have been implemented to date?
e. If a quality initiative has failed, what were the possible reasons for its failure?
f. How often do you maintain ISO 9000 standards?
g. What is the most commonly used model for quality e.g. MBQA, KAQA?

II. Lean Six Sigma information

a. Do you effectively communicate vision and mission, long-term quality goals and objectives vertically down the organization to achieve quality excellence? How?
b. How do you communicate the progress of LSS implementation across the organisation?
c. Do you measure the commitment of top management to the LSS programme? How do you measure that commitment? How committed are they?
d. How do you measure LSS success in the organisation e.g. financial benefits, employee morale, employee engagement and ownership?
e. How do you measure customer satisfaction?
f. How do you measure the Voice Of the Customer (VOC)? Do you use Kano model? If you do, in what context?
g. What are the challenges faced by LSS in aiming for Innovation and creating an Innovation culture?
h. Do you think that LSS fosters or hinders innovation culture?

3. <u>Financial Managers / Finance Team</u>

I. Background information

a. What is your level of education regarding finance?
b. What are your roles and responsibilities within the LSS initiative in the business?

II. Lean Six Sigma information

a. Do you measure financial benefits from LSS? If not, why?

b. What is your opinion regarding your company's employees' knowledge of financial information related to investments and savings from LSS?
c. What were the direct and indirect costs involved in the implementation of Lean Six Sigma? E.g. labour costs and consultancy fees.
d. Is there any investment in team selection and team building efforts, including training and outside facilitation?
e. What are the top three or five financial performance indicators used in your organisation?

4. <u>HR manager/ HR team</u>

a. How many people have been trained in LSS so far this year? Can you share what kind of reward system available for Lean Six Sigma (LSS) teams who complete projects successfully?
b. What is the role of HR in the LSS journey e.g. budgeting, training, promotions, annual appraisal for employees?
c. What other responsibilities do you have e.g. approving time for staff to attend training, serve on project teams?
d. How do you measure the effectiveness of LSS?

5. <u>Project Sponsors</u>

I. Background information

a. What is your level of education?
b. What are your roles and responsibilities within LSS initiative in the business?

II. Lean Six Sigma information

a. What are your responsibilities e.g. monitoring team progress, providing support as needed, sustaining the business results delivered by the project team?
b. What is the level of management involvement?
c. What are the skills required for people in carrying out LSS projects?

6. <u>Lean Six Sigma Project Champions</u>

I. Background information

a. What is your level of education regarding LSS?
b. What are your roles and responsibilities within LSS initiative in the business?
c. What other responsibilities do you have e.g. approving time for staff to attend training, serve on project teams?

II. Lean Six Sigma information

i. Training

a. Can you explain the LSS infrastructure?
b. How do you structure LSS improvement teams?
c. How do you select people for BB and GB training?
d. What were the difficulties encountered in training and how were they overcome?
e. How do you structure your BB, GB and YB training programme e.g. days of training, project requirements, nature of examination e.g. multiple choice exam, savings?

ii. Project selection

a. Is there a system developed by your organisation for project selection and priority? Which are the selection criteria?
b. How do you ensure that the project selected is aligned with the strategic business goals?
c. Who is responsible for selecting the right people for the Lean Six Sigma (LSS) projects?
d. Is there any motivation or reward programme to keep projects going?
e. How do you make sure that you are getting enough projects each year?
f. How do the employees propose projects to the champion e.g. use dashboard, through emails, visual management board?
g. How would you communicate the success of the projects?
h. Does the organisation have any failed projects? What were the causes of failure?

iii. Culture

a. What is the impact of organisational culture on LSS? How do you think LSS changes the culture?
b. Do you think the organisational culture in Saudi Arabia is in favour of LSS?
c. Do you believe that LSS can change the culture of Saudi Arabian companies? If not, why not? If it did, do you think that you will face more challenges compared to those in the US?
d. Do you think that the existence of international workers in Saudi Arabian companies will make culture change easier?

iv. Roadmap

a. Do you use any specific roadmap for LSS implementation? If so, could you please detail it?
b. How has the roadmap been developed?
c. What are the benefits of using a roadmap?

7. Master Black Belts / Black Belts

I. Background information

a. What is your level of education regarding LSS?
b. What are your roles and responsibilities within the LSS initiative in the business?
c. Do you work full-time or part-time?

II. Lean Six Sigma information

i. Training

a. How many hours of training have you received in order to be a MBB / BB?
b. Who has certified you as MBB / BB?
c. How has your LSS training been delivered e.g. External consultant, key customers, internally?
d. How would you judge the quality of LSS BB / MBB training? What characteristics influence the quality?
e. What additional training / work have you attended to become a MBB?
f. In your opinion, are there any weaknesses in the current curriculum in the MBB training e.g. soft skills and hard skills?

ii. Projects

a. How many projects do you have to complete a year?
b. Did you have to complete a minimum number of projects to be MBB?
c. On average, how long does a LSS project take to be completed?
d. What are the typical challenges in the execution of LSS projects?
e. Could you share an estimate of how much savings are you required to make per project / per year?
f. Can you share the best and the worst projects you have executed? What did you learn from these projects?
g. Do you spend 100% of your time on LSS projects?

iii. CSFs

a. What are the factors identified as critical to the success of LSS in the organisation, and how do they impact LSS?
b. What are the top five Critical Success Factors (CSFs) in your opinion?

iv. Benefits

a. What are the top five benefits gained from LSS deployment?

v. Communication

a. How do senior managers communicate what is expected from you and other LSS team members?

vi. Methods and tools

a. Do you use DMAIC as a framework for all projects?
b. What are the criteria for tool selection and how do you choose the tools for each specific LSS project and each phase of DMAIC?
c. Can you share the most commonly used tools across projects? Why were these selected?
d. Do you use Minitab for complex projects?
e. Have you experienced any issues in applying the selected methodology, e.g. statistical tools, people competency, etc.?

vii. Challenges

a. In the Lean Six Sigma (LSS) implementation process, which do you perceive as the main difficulties and obstacles, and how do you overcome them?

viii. Culture

a. Do you think the culture in your organisation supports LSS implementation?
b. Does the culture of the organisation support sharing information openly and freely, even bad news?
c. How does the culture of the organisation influence the fostering or inhibiting of innovation?
d. Do you perceive the leadership style as a catalyst for change? In your opinion which style works best?

8. <u>Green Belts</u>

I. Background information

a. What is your level of education regarding LSS?

b. What are your roles and responsibilities within LSS initiative in the business?

II. Lean Six Sigma information

i. Training

a. How many hours of training have you received in order to be a GB?
b. What skills are required as part of GB training programme?
c. Have you been trained in team working skills e.g. listening skills, brainstorming & discussion techniques, organising ideas, decision making?
d. Have you been trained in additional skills for effective team management e.g. goal setting, handling conflict, good decision-making, fostering continuous learning?

ii. Projects

a. How many projects do you have to complete a year?
b. How long does LSS project usually take to be completed?
c. What are the typical challenges in the execution of projects?
d. How much savings are you required to make per project / per year?
e. Do you use DMAIC methodology as a framework for solving all problems? Frequencies of using Lean or Kaizen.

iii. Leadership

a. One of the CSFs for LSS in literature is leadership; do you think leaders are showing full commitment for Lean Six Sigma (LSS) in your organisation? Why?
b. Do the leaders in your organisation have visible involvement and continued commitment to leading companywide quality initiatives e.g. being available to speak to staff, operating an 'open door' policy, walking the floor, holding briefings and feedback meetings?
c. In your opinion, what is the impact of leadership on LSS deployment? Does it bring forth a positive or negative impact? Why?

iv. Management support

a. Does your manager give you and your team members the trust and the power to make decisions?
b. How do you make decisions when a solution is derived from LSS methodology? Do you report to the manager at every step or are you empowered to take action?
c. Do you feel comfortable communicating with your manager to express your thoughts about the work at hand without fear of blame?
d. What are the typical communication challenges you face with your manager?

9. <u>Lean Six Sigma Team Members and Yellow Belts</u>

I. Background information

a. What is your level of education regarding LSS?
b. What are your roles and responsibilities within LSS initiative in the business?

II. Lean Six Sigma information

a. As an YB, do you execute projects?
b. To be an YB, what kind of training do you have go through?
c. What were the methods of assessment to become an YB?
d. As an YB how did you learn about LSS?
e. Has the senior management communicated the need for LSS?

f. Do your leaders understand and support continuous improvement (CI) by provision of appropriate resources, assistance, and removing stumbling blocks?
g. How would you describe your organisation's culture?

Table C.2.1: Critical Success Factors survey

Factors	Importance (1 – 5)	Practice (1 – 5)
1. Training and education	□ □ □ □ □	□ □ □ □ □
2. Top management involvement & support	□ □ □ □ □	□ □ □ □ □
3. Project selection and prioritisation	□ □ □ □ □	□ □ □ □ □
4. Availability of resources	□ □ □ □ □	□ □ □ □ □
5. Communication	□ □ □ □ □	□ □ □ □ □

Table C.2.2: Challenges for LSS implementation survey

Challenges	Practice (1 – 5)
1. Lack of awareness of LSS benefits to the business	□ □ □ □ □
2. Lack of leadership	□ □ □ □ □
3. Time consuming	□ □ □ □ □
4. Convincing top management	□ □ □ □ □
5. Resistance to change	□ □ □ □ □

To answer research question 2, What are the motivational factors for Lean Six Sigma deployment in Saudi Arabian organisations? The following queries will be made:

1. CEOs / Senior Managers
   a. What has been the primary motivation to deploy Lean Six Sigma (LSS) in your organisation?

2. Lean Six Sigma Project Champions
   a. What has motivated you to work as a LSS champion? Is it an intrinsic or extrinsic motivation?

3. Master Black Belts / Black Belts/ Green Belts
   a. What is your motivation to develop LSS programmes within the business?

To answer research question 3, how can the maturity level of Lean Six Sigma in Saudi Arabian organisations be effectively assessed? The following queries will be made:

1. CEOs / Senior Managers
   a. What is your knowledge regarding maturity models?
   b. Has your organisation used any model to assess the level of LSS maturity? If so, please give an example?
   c. In your opinion, what are the most important elements to be included in a maturity model e.g. maturity levels, characteristics, what to measure?

2. Lean Six Sigma Project Champions
   a. Do you think using a maturity model would be helpful for your organisation? Why?

3. Master Black Belts / Black Belts
    a. How has the company defined their level of maturity in Lean Six Sigma?
    b. Has your organisation used a model to assess the level of LSS maturity? If so, please give an example.
    c. In your opinion, what are the most important elements to be included in a maturity model e.g. maturity levels, characteristics, what to measure?

4. Green Belts
    a. Has your organisation used any model to assess the level of LSS maturity? If so, please give an example?
    b. In your opinion, what are the most important elements to be included in a maturity model e.g. maturity levels, characteristics, what to measure?

To answer research question 4, to what extent can the Saudi Arabian organisations participating in the case study be considered as learning organisations in the context of Lean Six Sigma? The following queries will be made:

1. CEOs / Senior Managers
    a. Does learning from mistakes apply in your organisation e.g. learn from failed projects? How?
    b. Is there a lead criterion for learning from other organisations experience e.g. benchmark organisations, competitors, other world-class organisations?

2. Lean Six Sigma Project Champions
    a. Do you encourage LSS team members to learn from their mistakes? How?
    b. Do you encourage LSS team members to learn from failed projects? How?

3. Lean Six Sigma Team Members
    a. Are people in your organisation enthusiastic about sharing and learning from each other? To what extent is your unit functioning as a learning organisation?

Table C.2.3: Organisational learning practices survey

Factors	Importance (1 – 5)	Practice (1 – 5)
Supporting learning environment:		
1. Psychological safety e.g. sharing information and problems, easy to speak and share what is in your mind	□ □ □ □ □	□ □ □ □ □
2. Appreciation of differences in opinions	□ □ □ □ □	□ □ □ □ □
3. Openness to new ideas e.g. new ideas are welcome, interest in better ways of doing things	□ □ □ □ □	□ □ □ □ □
4. Time for reflection and reviewing how the work is going	□ □ □ □ □	□ □ □ □ □
Concrete learning process and practices:		
1. Experimentation e.g. new ways of working, offering new products/services and dealing with new ideas	□ □ □ □ □	□ □ □ □ □
2. Information collection e.g. about competitors, costumers, and technology trends and comparing to the market	□ □ □ □ □	□ □ □ □ □
3. Analysis to identify and solve problems	□ □ □ □ □	□ □ □ □ □
4. Education and training	□ □ □ □ □	□ □ □ □ □
5. Information transfer e.g. meeting with other departments, external experts and customers	□ □ □ □ □	□ □ □ □ □

Leadership that reinforces learning:		
1. Good listener	□ □ □ □ □	□ □ □ □ □
2. Encourage multiple points of view	□ □ □ □ □	□ □ □ □ □
3. Invite input from others	□ □ □ □ □	□ □ □ □ □
4. Acknowledge his own limitations	□ □ □ □ □	□ □ □ □ □

Note: There are references for each interview question

C.3. Doctoral Research Interview Invitation

Lean Six Sigma Maturity Model

To Whom It May Concern

I am writing to seek your permission to conduct a research at your organisation for a study titled "Lean Six Sigma Maturity Model within Saudi Arabian Organisations: An Empirical Study".

This research is being conducted by me (Saja Albliwi, PhD student at Heriot-Watt University) as an integral part of my PhD program in School of Management and Languages. This study has been approved by the Ethics committee. As part of that approval process, I am required to obtain permission from the site where I conduct research.

The purpose of the research is to assess the current level of Lean Six Sigma adoption in Saudi Arabian organisations and to develop a maturity model for Lean Six Sigma that can help Saudi Arabian organisations to assess their level of Lean Six Sigma maturity.

The Model will be developed from different sources including literatures, surveys and interviewing people from industry such as you and your colleagues. Then the model will be modified according to the results of interviews with experts and consultants in the field of Lean Six Sigma around the world, and a copy of the final model will be sent to each company that contributed to this research.

I am interested to hear your experiences toward Lean Six Sigma deployment in your organisation. The interviews process is planned to not last for more than 90 minutes starting from mid-January 2015 to mid-April 2015. This will make very high contribution not only to my research but also to the field of Lean Six Sigma and in Saudi Arabia in particularly.

All responses will be treated with the utmost confidence and no single set of responses will be readily identifiable.

If you are willing to be involved, I am grateful if you could sign the form below acknowledging that you have understand the nature of the study being conducted, likely benefits of participation in this study, and you give permission for the research to be conducted at the site.

I………………………………………………………….as……………………………………of……
…………………… company have been fully informed as to the nature of the research to be conducted in: Lean Six Sigma Maturity Model within Saudi Arabian Organisations: An Empirical Study, give my permission for the study to be conducted.

Signature………………............................ Date …………………………………………

Kind Regards

Saja Albliwi

PhD Candidate
School of Management and Languages
Heriot-Watt University
Edinburgh, Scotland

C.4. Case Study Piloting

Cover Letter

Dear Sir/Madam,

I am currently pursuing a PhD in Lean Six Sigma at the Heriot-Watt University based in Scotland. My research –Lean Six Sigma Maturity Model within Saudi Arabian Organisations: An Empirical Study– aims to assess the current level of Lean Six Sigma adoption in Saudi Arabian organisations and to develop a maturity model for Lean Six Sigma that can help Saudi Arabian organisations to assess their level of Lean Six Sigma maturity.

To achieve the mentioned aims, the following research questions must be answered, for which the survey and the case study methods have been chosen.

- RQ1 What is the current level of adaption of Lean Six Sigma in Saudi Arabian organisations? (Survey and case study)
- RQ2 What are the motivational factors for Lean Six Sigma deployment in Saudi Arabian organisations? (Survey and case study)
- RQ3 How can the maturity level of Lean Six Sigma in Saudi Arabian organisations be effectively assessed?
- RQ4 To what extents can the Saudi Arabian organisations participating in the case study be considered as learning organisations in the context of Lean Six Sigma? (Survey and case study)

To gather the necessary information, the researcher will visit five organisations that are currently deploying Lean and/or Six Sigma. Managers and employees at different levels in each organisation have been carefully chosen as participants to ensure that sound and valid conclusions can be drawn from the study. Hence, the targeted interviewees are CEOs middle managers, Lean Six Sigma project champion, Master Black Belts / Black Belts, Green Belts and LSS team members.

The purpose of this letter is to invite you to review the semi-structured interview questions proposed for this study. This research would benefit from your experience and any comments or corrections that you suggest would improve the quality of the interview questions in terms of their relevance to the research aim, the clarity of the wording, or the inclusion of additional questions that could be asked that could serve to gather additional or detailed information. Your input and advice will be much appreciated.

Should you require any further information, please do not hesitate to contact me.
Yours sincerely,

Saja Albliwi

PhD Candidate
School of Management and Languages
Heriot-Watt University
Edinburgh, Scotland

D. Lean Six Sigma Maturity Model for Saudi Arabian Organisations

Dear Sir/Madam,

I am writing to invite you to participate in the Doctoral research that I am conducting in the context of Lean Six Sigma within Saudi Arabian organisations. One of the research aims is to develop a practical maturity model to assess the current level of Lean Six Sigma (LSS) maturity in Saudi Arabian organisations. The model is the result of a review of the available maturity models in the literature and interviews with 29 Lean and Six Sigma academics and practitioners in Saudi Arabia. The model consists of five maturity levels and six categories. The next stage after the model has been developed is to validate and test the model. I would like to ask you to have a look at the model and put down your comments to improve the model. Please feel free to move any activity from level to level or criticise the available activities.

Your feedback is very valuable to test the validity of the developed model. You were selected for this task because of your wide experience in Lean Six Sigma within Saudi Arabian organisations. The following section presents a brief explanation of the distribution for the maturity levels. This is followed by the proposed maturity model.

Level 0: Uncertainty
This level has been formalised for organisations that are unsure about the adoption of Lean or Six Sigma. Organisations at this level might have some people previously trained for LSS by previous organisations that they worked for. There is some degree of awareness in one department but no projects have yet been implemented using Lean or Six Sigma. Thus, this level is not considered to be a part of the maturity scale, since it is not a foundation for the other levels. At this level, the quality initiatives are limited to ISO standards and the company has basic awareness of basic quality improvement tools, such as cause and effect analysis, check sheets, and control charts whereas CI initiatives are rarely implemented or fail to be sustained. Therefore, this level is termed 'Uncertainty', as a result of managers and employees lack of knowledge on LSS and CI in general.

Level 1: Awareness
At this level, organisations are in the early stages of implementation and in the process of building the foundation and infrastructure for LSS. Hence, this level has been named 'awareness' because organisations at this level are trying to disseminate LSS awareness into different organisational levels by focusing on training and executing simple projects in one department and not across the business.

Level 2: Enlightenment
Organisations at this level have a more structured and systematic LSS approach than in level 1. This level has been named 'Enlightenment' because organisations at this level have the ability to understand and learn more facts and new practices in regard to LSS deployment. Organisations at this level are actively implementing projects in more than one department and generating more soft benefits and financial saving i.e. ROI of about 1:2 to 1:4.

Level 3: Capability
Organisations at this level have a strategic and planned LSS deployment. This level has been entitled 'Capability' because organisations that have reached this level are more proficient and capable to deploy LSS than those at levels 1 and 2.

Level 4: Certainty
At this level, employees try new ideas and do the work in innovative way. This level has been named 'Certainty' because LSS deployment becomes a belief and not only a method for improvement. The most important characteristics at this level are basic organisational learning practices, innovation, supportive leadership and some shifts in organisational culture are observed in this level.

Level 5: World-class level

World-class level is for organisations that are progressing to the same level as GE which is the benchmark for LSS in the world. At this level, the LSS approach is sustained and becomes a way of life, not just a fixing method. In order to reach this level organisations need more than 15 years, which requires changing the organisational culture and drives LSS into the DNA of the organisation.

Organisations need to select one activity in each category which is the most applicable to them:

Categories	Scores	Activities or Constituent behaviours and characteristics	
Infrastructure and training	0	Lack of training for employees and managers but there are some individuals trained for LSS by external specialists or consultants and there is a clear lack of internal expertise to solve business problems.	
	1	There is a formal LSS infrastructure in place to drive the initiative forward, supported by the senior management team. LSS training delivered for the most talented people, including YB, GB and BB.	
	2	Awareness of LSS at shop-floor level through the White Belt course and a larger number of people trained than in level 1.	
	3	All the above + development of a good LSS infrastructure, including WBs, YBs, GBs, BBs and possibly a MBB (if the number of employees is 1000 or more).	
	4	All the above + in-house training through MBBs and BBs and DFSS training in place.	
	5	All the above + Design for Six Sigma (DFSS) training is in place and BBs are capable of executing DFSS projects.	
Top management and leadership	0	Lack of top management commitment and involvement.	
	1	Senior management allocate resources to relevant LSS belts in pursuing projects and plan investment in LSS.	
	2	Senior managers attend performance meetings and LSS events.	
	3	All the above + assist LSS team to remove barriers to LSS success	
	4	All the above + top management involved in project selection, reviewing project benefits, supporting organisational learning behaviours and innovation.	
	5	All the above + all departments have a deployment champion for LSS reporting to the main champion in the organisations, with strong commitment from top management.	
Strategic alignment	0	Strategic goals are not clear and not linked to LSS and there is no strategy for CI in place.	
	1	The strategic goals of the organisation are formalised and linked to LSS.	
	2	Good problem definition, formulation and shared understanding among team members through effective teamwork.	
	3	All the above + each department's goals across the organisation have been aligned with LSS and projects are suggested based on this alignment.	
	4	All the above + some organisational learning practices are available and linked to LSS projects, e.g. sharing knowledge, learning from negative and positive experience.	
	5	All the above + LSS is culturally the way things are done, integrally aligned with the execution of the corporate strategy, and extends to customers, stakeholders, supply chain, and all business functions; organisational learning is extensively and widely distributed across the organisation, plus learning from competitors, and benchmarking with other organisations, locally and globally.	
Project selection and prioritisation	0	Project selection is by GBs or BBs and based on the most common problems.	
	1	Projects are selected on an ad hoc basis based on their importance in the organisation – primarily projects are selected based on Effort vs. Benefits model.	
	2	Projects are selected based on a set of criteria using a project selection matrix and there is some involvement of LSS champions in this exercise.	
	3	Projects are selected based on a set of criteria using a project selection matrix	

		and there is an active involvement of LSS champions in this exercise.	
	4	There is a well-defined and documented project selection methodology following a top-down approach and based on business strategy, with strong involvement of champions.	
	5	Projects are selected in a team environment, with very strong involvement of champions and VOC is fully utilised in project selection.	
Motivation and recognition	0	No recognition system in place with very low motivation for LSS across the organisation.	
	1	There is a small group of individuals in some departments who are motivated for LSS projects, although they are not getting rewards.	
	2	There is a formal reward and recognition system, but not well appreciated by the employees.	
	3	There is a formal reward and recognition system, which is well appreciated by the employees.	
	4	Employees and managers are intrinsically motivated for the development of LSS initiative.	
	5	Systematic rewards and recognition program for LSS team and belts created by HR and Finance departments.	
Financial Benefits (ROI)	0	ROI never measured or there is no financial return generated yet.	
	1	ROI is at least 1:1, starting from the first year of deployment.	
	2	ROI is 1:2 to 1:4.	
	3	ROI is approximately 1:5.	
	4	ROI is approximately 1:8.	
	5	ROI is more than 1:9.	
Total Score			

Please provide details about yourself
Years of experience in Lean/Six Sigma:
Number of Lean/Six Sigma projects you have curried out to date:
Job position:
Industry:

Your assistance and time taken to complete this test is greatly appreciated

Saja Albliwi

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