# Factors Critical To a Sustainable Deployment of Lean Six Sigma in Australian Business

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A thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Business Administration

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December 2013

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# Abstract

Over the last two decades, manufacturers in Australia have implemented process improvement methodologies to assist in driving down the costs of operations brought on by customers wanting better quality and responsiveness. Closely following in the footsteps of the manufacturers, since the early 2000's, are service organizations, including those in Healthcare, Finance/Banking, IT and Government (Public sector).

Lean Six Sigma is one such process improvement methodology. It is seen as the latest philosophy of continuous improvement in many companies world-wide. Lean Six Sigma is a combination of Lean Enterprise introduced by the Toyota Production System and Six Sigma introduced by Motorola's submission to the Malcolm Baldrige National Quality Award in the late 1980's. Essentially, Lean and Six Sigma have been combined since individually they cannot deal with all circumstances of problems.

Following an extensive literature review, it is clear that Lean Six Sigma has been based on earlier continuous improvement philosophies like Total Quality Management as well as the combination of Lean and Six Sigma. There are clearly some similarities and differences between Lean Six Sigma and Total Quality Management.

It is not clear in the literature whether companies are deploying Lean Six Sigma because the previous initiatives failed and it will result in better outcomes or it is a natural progression to adopt a new innovation and a new technique.

It is not clear if the drivers to deploy Lean Six Sigma are different to previous quality improvement initiatives. Total Quality Management was introduced in the 1980's to create a culture of continuous improvement, improve quality and enhance an organization's competitive advantage and it is interesting to establish if Lean Six Sigma has been deployed to deliver something else or the same since Total Quality Management did not deliver the expected benefits.

It is clear in the literature that Lean Six Sigma has been successful but success seems to vary according to the performance or success measure used. For example, if success is defined as higher market share then Lean Six Sigma may not be deemed successful but if success is defined as process cost reduction or savings resulting from an improvement project due to better delivery performance and process capability then it may be deemed successful. The literature covers the concept of a "Mature" deployment of Lean Six Sigma which is another way of measuring success apart from success from improvement projects. An organization which has a high level of maturity and where projects are successful is one that is likely to have a culture of sustainable continuous improvement.

Little attention has been directed towards how Lean Six Sigma should be deployed. Some companies have deployed Six Sigma first then Lean and other companies have deployed Lean first to identify low hanging fruit and then implemented Six Sigma and others have implemented the combined program from day one. Also, the literature suggests that deployment of Lean Six Sigma needs to be different in small and medium-sized organizations.

In the literature, it is clear that the phases of a Six Sigma methodology (Define-Measure-Analyze-Improve-Control) are well-defined but there has been little attention given to the definition of what constitutes a Lean Six Sigma methodology. For example, in many companies Lean Six Sigma deployments use the DMAIC methodology and also use Lean tools at various stages and in others Lean is separately deployed concurrently with DMAIC.

Factors critical to success of Lean Six Sigma have been identified in the literature. It is unclear whether these factors are critical to short-term gains or long-term sustainable benefits. This phenomenon also seems to be the case for Total Quality Management (TQM) implemented by many organizations around the world during the 1990's. Included in these critical success factors for Lean Six Sigma is the need for highly-trained Lean Six Sigma experts, known as Master Black Belts and Black Belts (and other levels of "Belts") and the importance of corporate or organizational factors. In the literature the concept of a competency-based perspective of these factors is introduced.

In Australia, Lean Six Sigma has been deployed successfully in many companies involved in manufacturing and service, both large and small and medium-sized and in the public sector. However, it has been disbanded in some companies because of an apparent failure of the program, which also appears to be the case for some Total Quality Management deployments. It is unclear as to why this has happened but it is suggested that it is so due to the different measures of success of the program.

Also in Australia, some anecdotal evidence suggests that the ongoing deployment of Lean Six Sigma is susceptible to a change of the Chief Executive Officer of the organization. Other evidence suggests that the companies that disbanded the program some years ago are re-deploying it using funding provided by the Australian Federal and State Governments.

Further evidence suggests that the Lean Six Sigma programs are now becoming very successful in many other industry sectors like Healthcare and Government in Australia.

Thus, in this thesis the researcher considers the following research questions relating to a Lean Six Sigma deployment.

1. What are the key drivers and success measures of a Lean Six Sigma deployment?
2. How has Lean Six Sigma been deployed and is it affected by organizational size?
3. What are the competencies of an organization that result in the successful deployment of Lean Six Sigma?
4. What are the personal competencies of the deployment leader and project leaders for the Lean Six Sigma deployment to be successful?

5. What success factors are common between Lean Six Sigma and previous quality improvement initiatives such as Total Quality Management (TQM)?

In developing and examining these questions, a comprehensive literature review and four fieldwork phases involving qualitative and quantitative research was completed. There are two fieldwork phases using qualitative research (fieldwork phases 1 and 3) and two fieldwork phases using quantitative research (fieldwork phases 2 and 4).

Fieldwork phase 1 (Chapter 4) involves face-to-face interviews using semi-structured questions with senior managers in organizations in Australia that have deployed Lean Six Sigma. Seven case organizations have been selected – four cases in manufacturing and three in service. This has revealed a number of significant issues relating to key drivers, deployment strategies, critical success factors and challenges and benefits of the deployment. Factors critical to success include organizational competencies and competencies of the experts involved in Lean Six Sigma.

Fieldwork phase 2 (Chapter 5) considers an in-depth analysis of Lean Six Sigma in one of the seven organizations. The aim of fieldwork phase 2 was to gain insights into the relationship between critical success factors and performance measures for this case. The case was in Healthcare and was chosen as a result of the interest of the interviewee in fieldwork phase 1 to examine their improvement program more fully using input from all senior managers.

Fieldwork phase 3 (Chapter 6) involves the use of an open questionnaire with two Lean Six Sigma experts. The aim of fieldwork phase 3 was to gain further insights into the required competencies of the Master Black Belt and Black Belt in Lean Six Sigma.

Using the insights from fieldwork phases 1, 2 and 3, a model for the sustainable deployment of Lean Six Sigma program was developed.

Sustainability is defined as the combination of successful projects and a level of maturity of the Lean Six Sigma deployment.

Fieldwork phase 4 (chapter 7) involves testing the developed model using a National Survey of Operations Excellence Managers in Australian organizations that have deployed Lean Six Sigma. The aim of fieldwork phase 4 is to obtain objective evidence of what factors are critical for a sustainable Lean Six Sigma deployment.

A number of key insights are revealed contributing to the theory and practice of Lean Six Sigma. A discussion of the key insights are presented in chapter 8 followed by conclusions and recommendations being presented in chapter 9.

# Declaration

I hereby declare that this thesis contains no material that has been accepted for the award of any other degree or diploma in any university or equivalent institution and that to the best of my knowledge and belief, this thesis contains no material previously published or written by another person, except where due reference is made in the text.

Signed: ____________________________________________________

Roger John Hilton, researcher

# Acknowledgements

I acknowledge the support and love from my darling wife Rosslyn. I also thank Professor Amrik Sohal for his friendship over many years and his expert and strategic guidance in reviewing this thesis and his important contribution to a number of publications along the way.

# Publications resulting from this study

The research conducted for this DBA has resulted in the following publications.

Peer Reviewed Journal Articles

- Hilton, R., Balla, M. & Sohal, A. S. (2008). Factors critical to the success of a Six-Sigma quality program in an Australian hospital. *Total Quality Management & Business Excellence,* Vol. 19**,** No. 9, pp.887-902.
- Hilton, R. & Sohal, A. (2012). A conceptual model for the successful deployment of Lean Six Sigma. *International Journal of Quality and Reliability Management,* Vol. 29**,** No. 1, pp. 54-70.

Conference Papers

- Hilton, R (2004). Six Sigma Applications in Australia: Performance Impact and implementation strategies in a number of case study companies. *In* Edited Conference Proceedings for First International Conference on Six Sigma at Glasgow Caledonian University, UK, 16th-17th December 2004
- Hilton, R. (2010). A conceptual model for the successful deployment of Lean Six Sigma. *In:* ANZAM, ed. 8th ANZAM Operations, Supply Chain and Services Management Symposium, Sydney, Australia, 6-8 June, 2010 Sydney
- Hilton, R. (2010). Research into the sustainability of a Lean Six Sigma deployment in Australia – a predictive model. *In* Proceedings of ISFSAM – World conference in Justice and Sustainability in a Global Economy, Paris, France 8th – 10th July, 2010.

# 1. Chapter One: Research Background

## 1.1 Introduction

This chapter serves the purpose of introducing the reader to the thesis covering the background to the study, objectives of the research, why Australia has been chosen, the research questions, the research methodology and the assumptions and limitations of the research.

## 1.2 Background to the research

Over the last few decades a number of continuous improvement initiatives have been implemented within both large and small to medium-sized organizations within manufacturing and service industries. These quality improvement initiatives include Quality Management Systems (ISO9001 and TS16949), Total Quality Management (TQM), Business Process Reengineering (BPR), Six Sigma, Lean manufacturing, Just-In-Time, TRIZ (theory of inventive problem solving), Lean Six Sigma and Business Excellence Systems (e.g. Australian Business Excellence Framework; Malcolm Baldrige National Quality Award in the US).

Some of these continuous improvement initiatives have survived and others have fallen away and been replaced by a successor. The definition and scope of each of these continuous improvement initiatives has varied considerably and also there is evidence of similarities ranging from similar factors critical to success of the initiative (Näslund, 2008) to common strategic and philosophical themes to deployment (Dahlgaard and Dahlgaard-Park, 2006; Ferguson, 2007).

There is evidence in the academic literature of similarities between these improvement initiatives from the aspect of quality, statistical and other tools used but significant differences have also been highlighted relating to use of data and measurement, philosophical issues and financial aspects (Andersson, Eriksson and Torstensson, 2006; Näslund, 2008).

There is some well publicized evidence that some organizations that have deployed these quality management initiatives have been very successful and some have failed. For example, General Electric under Jack Welch was instrumental in implementing Six Sigma across the business units resulting in a significant financial benefit to the bottom line (Lucier and Seshadri, 2001). Other companies have started with a quality initiative and then either changed to the latest "fad" or disbanded it completely since it was not able to have lasting impact on the business (Antony, 2007; Hyett, 2004; Näslund, 2008).

Some practitioners and academics have suggested that TQM has failed (Brown, 1994; Cao, Clarke and Lehaney, 2000; Eskildson, 1994; Harari, 1997; Nwabueze, 2001) and some have suggested that Six Sigma has failed (Boucher, 2012). Others have suggested that Lean is easier to implement than Six Sigma and others have said that both Lean and Six Sigma should be leveraged from TQM or a focus on quality and process improvement (Antony, 2011).

Lean Six Sigma has been around for many years in different forms and is not new. It is a combination of the Lean Enterprise introduced through the Toyota Production System (Womack and Jones, 1994) and Six Sigma introduced as part of Motorola's submission for the Malcolm Balridge National Quality Award (Harry, 1998). The methodology has also incorporated the principles and practices from other improvement methodologies including TQM (Prajogo and Brown, 2004) to be the present day Lean Six Sigma program.

Some authors have described why they have combined Lean and Six Sigma which is essentially because individually Lean and Six Sigma cannot deal with all circumstances of problems (George, 2003). The evolution of Lean Six Sigma has taken place since maintaining high production rates and high quality, or producing less waste, simply does not address enough areas that require improvement. For example, Lean cannot bring a process under statistical control and Six Sigma alone cannot dramatically improve process speed or reduce invested capital (Bhuiyan and Baghel, 2005).

Some authors have defined the phases of a Six Sigma methodology (Hahn, Hill, Hoerl and Zinkgraf, 1999) but there has been little attention given to the definition of what constitutes a Lean Six Sigma methodology and little attention has also been paid on how Lean Six Sigma should be deployed (Gershon and Rajashekharaiah, 2011).

Factors critical to success of Lean Six Sigma have been identified by many academics and practitioners for both large and small and medium sized companies (Deshmukh and Chavan, 2012; Näslund, 2013; Nurul Fadly and Sha'ri Mohd, 2013; Prasanna and Sekar, 2013; Sharma and Chetiya, 2012; Timans, Antony, Ahaus and Van Solingen, 2012).

However, success for many deployment has only really been associated with short-term gains rather than long-term benefits (Huq, 2006). This latter phenomenon seems to be the case also for TQM, which is possibly why TQM was previously debated as being either "Dead" or "Alive" (Filipczak, 1993). Many researchers have defined success by savings or reduced costs and/or other tacit benefits such as customer or employee satisfaction (Leipold, 2007). Most of these measures seem to be short-term focused which is possibly why some companies change their program deployments and/or introduce other improvement methodologies or just focus on Lean rather than Six Sigma (Huq, 2006).

Over the period from 1992 to 2008, there have been 417 published articles on Six Sigma and related topics including Lean (Gamal, 2010). These articles have been focused on the topics as presented in Figure 1.1. Another comprehensive review of the Six Sigma literature has been provided by Tjahjono, Ball, Vitanov, Scorzafave, Nogueira, Calleja, Minguet, Narasimha, Rivas, Srivastava, Srivastava and Yadav (2010).

There has been a significant growth of research articles on Lean Six Sigma between 1992 and 2013 with a large proportion of articles being written after 2010 indicating that there has been a significant increase in the research on the topic of Lean Six Sigma annually.

Many of these articles cover case examples on Lean Six Sigma in different industry sectors including manufacturing, Healthcare, Finance and Banking. Relevant articles on Lean Six Sigma for this research study are referred to in the literature review in Chapter 2.

Although much important work has been documented regarding Lean Six Sigma, a number of questions still remain. These relate to the key drivers for Lean Six Sigma, the success measures for Lean Six Sigma, the different types of Lean Six Sigma deployment models in different organizations, the factors that are critical to the successful deployment of the initiative in the long-term and the common success factors between Lean Six Sigma and other quality improvement initiatives such as Total Quality Management (TQM). These questions are the research questions developed and discussed further in the literature review presented in sections 2.6 to 2.9 of Chapter 2. The specific research questions are listed in section 1.5 below.

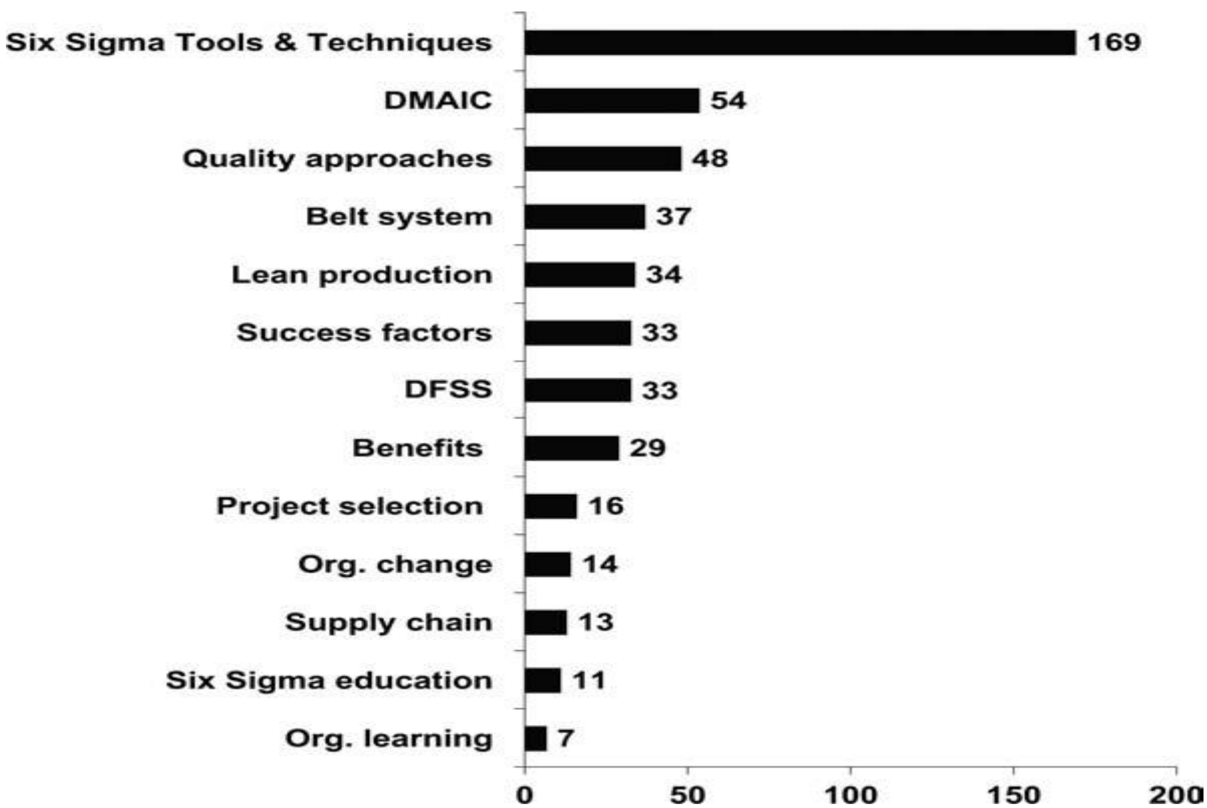


Figure 1.1: Frequency of research topics published in Lean, Six Sigma or related topics between 1992 and 2008, Source Gamal (2010)

## 1.3 Objectives of the Research

Missing from both the practitioner and academic literature is a clear picture of how the deployment of Lean Six Sigma can be successfully sustained in the long-term. "Sustainability is not a method or a tool, it is the state of a company in which the efficiency of resources is maximized, customers are satisfied to a great extent, an improved condition is long-lasting, success is maintained and competitive advantage is sustained" (Abdullah, 2011, p51). Hence, this research focuses on developing a model that will allow practitioners to gain insights into what factors are critical in order that a Lean Six Sigma deployment is sustainable in the long-term and how it can be part of the company's culture or DNA.

Success of a quality initiative can be short-term or long-term. Short-term success appears able to be achieved but long-term success is not always possible since there is an expected level of maturity of Lean Six Sigma (Näslund, 2008). Some researchers have used project success as the measure of success. Thus, if an organization is continually looking at project improvements then this tends to suggest sustainable practice but this may not be the case. In this research, sustainable deployment of Lean Six Sigma is defined as a combination of the level of "maturity" of the program and the benefits arising from the Lean Six Sigma improvement projects.

As such, the objective of this research is to identify how organizations create long-term success through the deployment of a quality initiative (Andersson *et al.*, 2006) with particular reference to Lean Six Sigma and using an Australian context. A key objective of the research is the development of a model to predict the conditions for a sustainable deployment of a continuous improvement model like Lean Six Sigma. This model for Lean Six Sigma deployment is described by a relationship between a response measured by the level of maturity of an organization and the success of projects and a number of explanatory variables.

The factors in this model are developed through the research questions, which are listed in section 1.5. The discussion on research question 1, relating to key drivers and success for Lean Six Sigma provide insight into the maturity of a deployment which is one of the response variables of the model. The discussion on research question 2 relating to Lean Six Sigma deployment strategies and models provides insight into the type of improvement project deployed, which is a second response variable. The discussion on research questions 3 and 4 relating to organizational competencies and personal competencies respectively provide insight into the constructs for each of the explanatory variables.

This research also identifies the common factors that are critical to success for any quality initiative and this leads to research question 5 relating to deriving the success factors that are common between Lean Six Sigma and previous quality improvement initiatives such as TQM?. It is argued in this study that there are a number of common elements that are necessary for the long-term success of any one of the quality improvement initiatives including Lean Six Sigma and TQM.

## 1.4 The Australian Context

In Australia, over the last three decades, different quality management initiatives have been applied by organizations in manufacturing, finance, government and many other service sectors, both large and small and medium-sized. These initiatives have included Quality Management Systems (ISO9001 and TS16949, the automotive supply chain equivalent), TQM, Business Process Reengineering, Six Sigma, Lean manufacturing, Just-In-Time, Lean Six Sigma and Business Excellence frameworks like the Australian Business Excellence Framework.

In Australia, evidence of these deployments can be seen from the following:

- Victorian Government based initiatives like the Innovations Insights program (Insights2Excellence, 2008)

- Companies being trained under the Federal government Workplace training courses in Competitive Manufacturing who have implemented versions of Lean and Six Sigma (NTIS, 2008)
- Papers presented at a number of Lean and/or Six Sigma conferences held by International Quality and Productivity Council (IQPC, 2010) and the Lean Six Sigma Division of the Australian Organization for Quality (AOQ, 2010)
- The number of member companies of the Australasian Association of Six Sigma Practitioners, who have adopted Six Sigma and Lean Sigma initiatives (AASSP, 2010) – The Australasian Association of Six Sigma Practitioners is a group of practitioners whose members are Master Black Belts of the large companies in Australia including representatives from Banks, Service and Health providers and Manufacturers
- The member companies of the Association of Manufacturing Excellence who have adopted Lean Manufacturing principles - (AME, 2008)
- An increasing number of Lean and/or Six Sigma Training providers
- Existence of many advertisements for Lean Six Sigma consultants and facilitators (Seek, 2008).

In Australia, large multinationals have deployed both Lean and Six Sigma across the company investing heavily in training and development whilst some small and medium-sized enterprises have deployed cut-down versions of Six Sigma or Lean Six Sigma, still resulting in significant gains to the company's performance with relatively moderate investment in training and development (refer fieldwork phases 1, 2 and 4).

Some organizations that have deployed these quality management initiatives have been successful and some have failed. There is evidence of some organizations reducing their focus on Six Sigma and concentrating on Lean and a number of organizations disbanding the combined improvement program altogether. For example, in an article by Ferguson (2003), it was noted that a large Telco's business transformation project is being driven through the Six Sigma business process improvement techniques, with more than 150 such projects underway and 1,900 people trained over the previous two years. The carrier said it had booked AU$30 million in 2002/03 in savings related to Six Sigma projects and expects this to grow substantially as projects are delivered (Ferguson, 2003). It is well known that there is less emphasis on Six Sigma in this Telco in Australia since the replacement of the then CEO.

There is evidence in Australia also of significant movement of deployment leaders of Lean Six Sigma between companies, for example, holding positions in Lean Six Sigma over seven years in five different companies (refer fieldwork phase 4). However, there is some recent comments about the re-emerging of Lean and Six Sigma in Australia following the Global Financial Crisis (Potamianakis, 2010).

Finally, little attention in either qualitative or quantitative academic research in Lean Six Sigma sustainable deployment strategies has been applied to organizations in Australia.

## 1.5 Developing the Research Questions

Following on from the issues and concepts raised in in sections 1.2, 1.3 and 1.4 above, a number of research questions have be developed. These research questions are developed fully in the literature review in chapter 2 and are then are explored further in the discussion in chapter 8 and conclusions and recommendations in chapter 9 using insights gained from fieldwork phases 1 to 4. There are five research questions and these are listed below.

Research Question 1: What are the key drivers and success measures of a Lean Six Sigma deployment?

Research Question 2: What are the characteristics of the way Lean Six Sigma has been deployed and is it affected by organizational size?

Research Question 3: What are the competencies of an organization that result in the successful deployment of Lean Six Sigma?

Research Question 4: What are the personal competencies of the deployment leader and project leaders for the Lean Six Sigma deployment to be successful?

Research Question 5: What success factors are common between Lean Six Sigma and previous quality improvement initiatives such as TQM?

Table 1.1 presents which sections of the thesis each research question is developed and discussed.

| Research Question | Developed in literature review section | Discussed in chapter 8 and chapter 9 sections |
|---|---|---|
| 1 | 2.6.6 | 8.2, 9.2.1 |
| 2 | 2.7.7 | 8.3, 9.2.2 |
| 3 | 2.8.3 | 8.4, 9.2.3 |
| 4 | 2.8.4.5 | 8.5, 9.2.4 |
| 5 | 2.9.4 | 8.6, 9.2.5 |

Table 1.1: Sections of the thesis in which each research question is developed and discussed

## 1.6 Research Framework Overview

The research has involved two key areas – a comprehensive literature review and a number of fieldwork phases. The fieldwork has involved a mixed method approach including face-to-face interviews using semi-structured questions, one in-depth case study, an open questionnaire and a National quantitative questionnaire survey. The phases of this research commenced with a literature review, followed by seven case studies involving face-to-face interviews using semi-structured questions for companies in manufacturing, health, banking and service, followed by one in-depth study of a Hospital, followed by two open questionnaires to experts in Lean Six Sigma and finally a National survey of facilitators of Lean Six Sigma in Australian organizations across many industry sectors. Figure 1.2 describes the phases and the link with each research question.

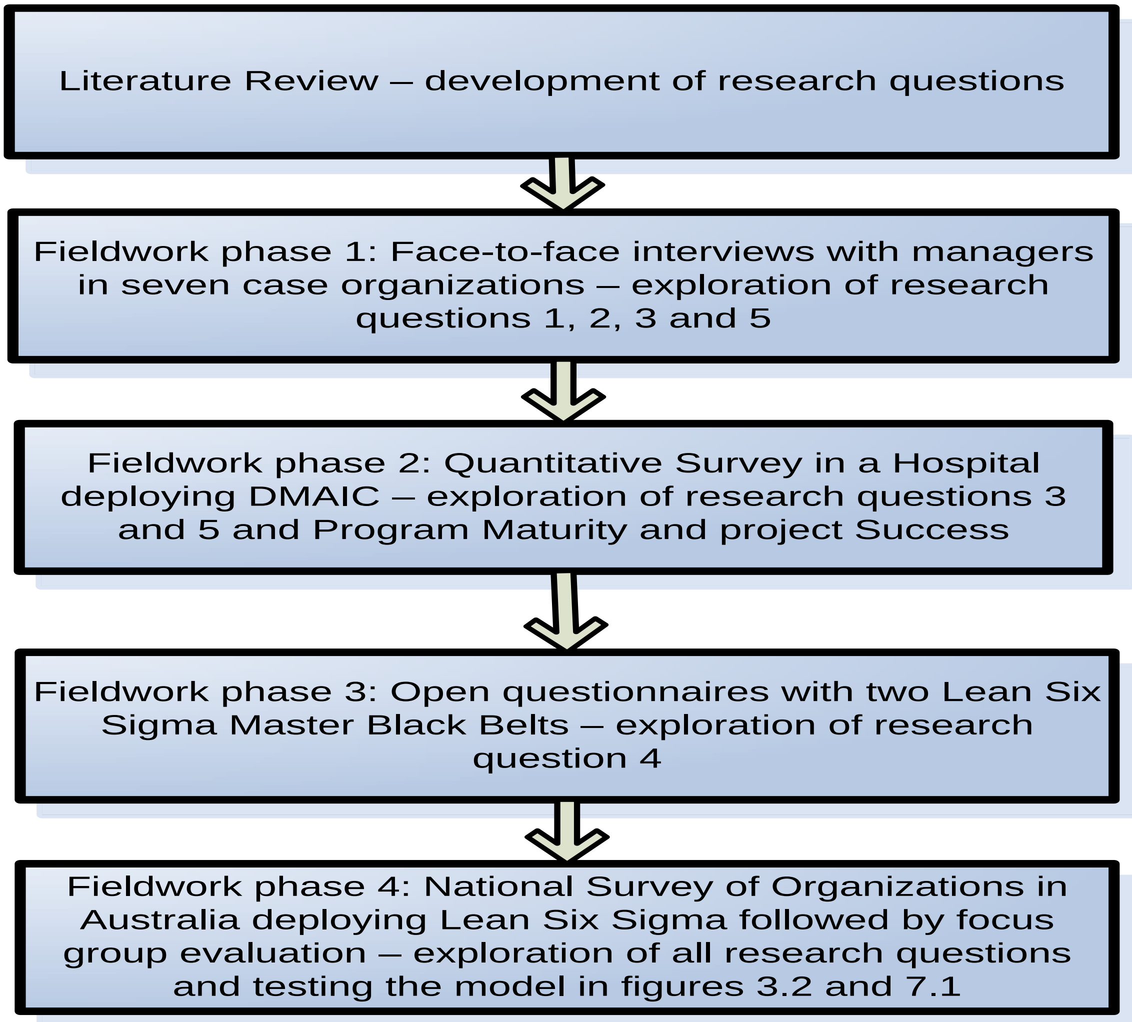


Figure 1.2: Phases of the Research

## 1.7 Structure of the thesis

In chapter 1, the background to the research, the objectives of the research, an explanation of the Australian context, the research questions, the research framework and the assumptions and limitations are presented.

In chapter 2, a review of the literature on Lean Six Sigma is presented. The review is divided into two parts – the first part provides the key definitions and performance of the quality improvement programs relevant to this research namely, TQM, Six Sigma, Lean and Lean Six Sigma and a comparison between these initiatives and the second part develops the research questions.

In chapter 3, the research framework and methodology is described. The chronological order of the research, namely the face-to-face and semi-structured interviews for seven case organizations, the in-depth case study using a quantitative questionnaire, an open questionnaire and the National survey is presented. The research methodology using both qualitative and quantitative research is presented.

Chapter 4 discusses the results of the fieldwork involving the face-to-face interviews using semi-structured questions for the seven case organizations.

Chapter 5 presents the results of the in-depth study for the case in Health using a quantitative questionnaire.

Chapter 6 presents the results of an open questionnaire to two senior and experienced Master Black Belts.

Chapter 7 presents the results of a National survey across a sample of Operational Excellence and Quality executives (Master Black belts or their equivalent) from a number of organizations in Australia.

In chapter 8, an overall discussion of the research questions is presented and finally in chapter 9, conclusions and recommendations and the contribution to Lean Six Sigma theory and practice is presented.

The partial requirements to satisfy the DBA comprise three Stages. Stage 1 represents the literature review of Lean Six Sigma presented in Chapter 2. Stage 2 comprised fieldwork phases 1, 2 and 3 (face-to-face interviews, in-depth study and open questionnaire) presented in Chapters 4, 5 and 6 respectively. Stage 3 was the National survey work presented in Chapter 7.

## 1.8 Assumptions and Limitations

### 1.8.1 Assumptions

The following assumptions are recognised as implicit while conducting this study:

- Interviewees were able to adequately understand and comprehend the questions asked in the sense conveyed by the researcher
- Responses of the interviewees were sincere and accurate
- All interviewees adequately captured the position of the organisation in relation to the questions
- Some respondents may have been speaking on behalf of the wider organisation or the context of the industry
- All respondents to the surveys adequately captured the position of other experts and the organization in relation to the questions.

### 1.8.2 Limitations

This study recognises the following limitations:

- The analysis undertaken is based on the responses and perceptions of the interviewees at a particular point in time
- Generalizability of the results of this study to other contexts should be done with caution particularly across industry sectors due to the size of the sample.

## 1.9 Summary of Chapter 1

This chapter has provided the background to the study, the objectives of the study, the Australian context, has listed the research questions, has provided an overview of the research framework, has explained the structure of the thesis, has described the requirements to satisfy the DBA and finally has listed the assumptions and limitations.

# 2. Chapter Two: Literature review

## 2.1 Introduction

This chapter has two parts. The first part is covered by sections 2.2 to 2.6 and the scope of each of these sections presents a review of the literature specifically on the definitions and the performance of Total Quality Management (TQM), Six Sigma, Lean Manufacturing and Lean Six Sigma respectively. The articles excluded in sections 2.2 to 2.6 relate to those articles which do not mention definitions or performance of any of the initiatives. The first part concludes with a comparison of TQM, Six Sigma, Lean and Lean Six Sigma.

The second part is covered by sections 2.7 to 2.10 and specifically deals with the five research questions. The first research question (a review of the drivers and success measures for Lean Six Sigma) is developed in section 2.7. The second research question (a review of the deployment strategies and models for Lean Six Sigma) is developed in section 2.8. The third and fourth research questions (a review of the organizational competencies to support Lean Six Sigma and personal competencies of the Lean Six Sigma deployment facilitator and project leaders) are developed in section 2.9. Finally, the fifth research question (a review of the critical factors for success of TQM and Lean Six Sigma) is developed in section 2.10.

In particular, the short-comings developed from the review of the literature for the first research question allows for the inclusion of the concept of maturity as a measure of success of Lean Six Sigma and a response variable in the model of sustainable deployment of Lean Six Sigma (refer fieldwork phase 4).

## 2.2 Total Quality Management (TQM)

TQM started in Japan although many original ideas came from the US, especially from Deming (1986) and Juran (1989). Deming's basic quality philosophy was that efficiency improves as variability decreases. TQM has been shown to be an evolving system of practices and tools and training methods (Shiba, Graham and Walden, 1993) and evolved from inspection to quality control and later to quality assurance (Dale, 1999).

According to Dahlgaard *et al* (1999), TQM developed into a corporate culture characterized by increased customer satisfaction through continuous improvement, in which all employees in the firm actively participate.

Hellsten and Klefsjö (2000) support the view that TQM is an evolving system and define TQM as a continuously evolving management system consisting of values, methodologies and tools, the aim of which is to increase external and internal customer satisfaction with a reduced amount of resources. Hellsten and Klefsjö (2000) argue that a methodology consists of a number of activities performed in a certain way and defines tools as rather concrete and well-defined tools, which sometimes have a statistical basis, to support decision-making or facilitate analysis of data. Tools that are frequently mentioned in the TQM literature include the seven quality control tools (Ishikawa, 1985; Shewhart, 1938) and the seven management tools (Mizuno, 1988). The improvement cycle is also a common methodology in order to improve the business, according to Evans and Lindsay (2005). The improvement cycle is composed of four stages: plan, do, study and act (PDSA).

Easton and Jarrell (1998) defines TQM to be a management system that substantially addresses the MBNQA criteria namely process focus, systematic improvement, company-wide emphasis, customer focus, management-by-fact, employee involvement and development, cross functional management, supplier performance and relationships and recognition.

TQM is also a philosophy of continuous improvement (Andersson *et al.*, 2006; Evans and Lindsay, 2005). The introduction of TQM has played an important role in the development of contemporary management. Quality has become the key slogan as organisations strive for a competitive advantage in markets characterised by liberalisation, globalisation and knowledgeable customers (Sureshchandar, Chandrasekharan and Anantharaman, 2001).

The purpose of TQM, as with any change method, is to improve organizational performance (Näslund, 2008). TQM emphasizes the importance of satisfying customer requirements in terms of availability, delivery, reliability, maintenance and cost effectiveness (Al-Mashari and Zairi, 2000). Vokurka *et al.* (2000) argue that, with customers demanding quality and competitors responding to such demands, business turned to TQM as the key to enhance overall performance.

There are many different approaches to evaluating the possible benefits of TQM. Historically, one of the most common ways to quantify the benefits of quality has been to estimate the costs of poor quality (Juran, 1989). Later research has shown that one of the goals of TQM namely customer satisfaction, has a significant positive impact on market value as well as accounting returns (Andersson and Fornell, 1994).

Hendricks and Singhal (1997) demonstrated, using 600 organizations who have won quality awards by independent award-givers and by customers of the recipients that TQM has a significant impact on performance compared to similar companies from the S&P 500. Lemak and Reed (1997) claimed that TQM leads to an improved profit margin, after studying 60 companies that had demonstrated a commitment to TQM for a period of at least five years.

The failures of TQM implementation have also been well documented (Brown, 1994; Cao *et al.*, 2000; Eskildson, 1994; Harari, 1997; Nwabueze, 2001). In particular, Harari (1997) states that, after studying all the independent research conducted by consulting firms, the conclusion is that only about one-fifth, or at best one-third, of the TQM programs in the US and Europe have achieved significant or even tangible improvements in quality, productivity, competitiveness or financial results.

Eskildson (1994) stated, on the basis of survey results, that many organizations do not succeed in their TQM efforts due to a vague definition of TQM. As a solution to this issue, Pyzdek (1999) states, after summarizing some criticism against TQM, that TQM professionals constantly need to seek to improve the knowledge of quality and the methodologies for attaining it in order to manage the changing concept of TQM.

In conclusion, TQM has been evolving as a management philosophy and still exists today. It focuses on a number of metrics (quality, reliability and cost reduction), involves everyone in the organization, and trains some to use statistical tools and an improvement cycle. TQM has been shown to be successful but has failed in some companies and hence some confusion exists into how it should be deployed and how it can be sustained.

## 2.3 Six Sigma

The origin of Six Sigma can be traced back to Motorola in 1987 in their quest to reduce defects of manufactured electronics products (Rancour and McCracken, 2000). In 1988, Motorola received the Malcolm Baldrige National Quality Award (MBNQA), which led to an increased interest of Six Sigma in other organizations (Pyzdek, 2001). One of the original definitions of Six Sigma was a quality program aimed at the near elimination of defects from every product, process and transaction (Hahn *et al.*, 1999) but has gained wide acceptance as an improvement methodology to enhance an organization's competitiveness in many other companies world-wide both large and small and medium-sized (Lee and Choi, 2006).

A number of interpretations of Six Sigma have been identified in the literature. As such, the scope of Six Sigma has been interpreted differently within various organizations adopting it and hence creating confusion. These interpretations include a set of statistical tools, an operational philosophy of management, a business culture and an analysis methodology that uses the scientific methods, although the streams are not mutually exclusive but instead, overlapping (Tjahjono *et al.*, 2010). Other interpretations have included a quality management philosophy as well as a methodology that focuses on reducing variation, measuring defects and improving the quality of products, processes and services (Furterer and Elshennawy, 2005).

Anthony and Banuelas (2002) comment that, in the business world Six Sigma is a business strategy used to improve business profitability, to improve the effectiveness and efficiency of all operations to meet or exceed customer's needs and expectations. Hoerl (2004) discusses the Six Sigma methodology from a statistical, probabilistic and quantitative point of view. From the statistical point of view, the term six sigma is defined as having less than 3.4 defects per million opportunities or a success rate of 99.9997% where sigma is a term used to represent the variation about the process average (Antony and Banuelas, 2002).

Statisticians may notice that having specification limits six standard deviations away from the average of an assumed normal distribution will not result in 3.4 defects per million. Supporting this definition, Six Sigma has also been defined as a very rigorous quality control concept where many organizations still perform at a three sigma level (McClusky, 2000). This ultimate goal of Six Sigma has led to confusion about Six Sigma goals. In a more recent article, it is suggested that there is a need to find a new algorithm that can be used for calculating the overall sigma level of a multistage system which exists in many complex processes (Yahia Zare, 2011). Further, there are mistakes implicit in blindly conforming to the standard Six Sigma goal of 3.4 defects per million (Maleyeff and Krayenvenger, 2004).

The management consulting firm Rath & Strong (2006) conducted a number of interviews with senior Six Sigma practitioners and other Quality Management experts including Bob Galvin, Mikel Harry and Joseph Juran. In the interview with Bob Galvin from Motorola, Galvin is reported as stating in 1985 that Six Sigma was an integration of all the quality strategies that were already in existence at Motorola for example, participative management, problem solving using Pareto Analysis and the application of Juran’s quality principles. Also, Galvin suggested that Motorola had a supporting culture of listening, education and participation.

General Electric (GE) embraced Six Sigma very passionately under CEO Jack Welch, and GE became the Six Sigma benchmark with respect to deployment.

Welch (1999) commented that the adoption of Six Sigma at GE directly drove increased operating profit margins, reduced cycle time, increased employee productivity, improved customer satisfaction and minimized production defects. However, this came at the expense of many staff leaving GE since they did want to be involved.

Both Welch and Larry Bossidy, as CEO of Allied Signals (now Honeywell) created environments in which Six Sigma could thrive (Gupta, 2004). Following GE and Allied Signal's implementation, Six Sigma was launched all over the world and many other companies, initially mostly US large companies including Lockheed Martin, Polaroid, Sony, Honda, American Express, Ford, Lear Corporation and Solectron.

Eventually, Six Sigma was implemented in organizations in Finance/Banking (Senol and Anbar, 2010), Health (Behnke and Breyfogle, 2005; Lazarus and Novicoff, 2004), Safety (Revelle, 2004), Human Resources (Heuring, 2004) and Credit Unions (Roberts, 2004) and small and medium-sized organizations (Antony, Kumar and Madu, 2005; Davies, 2005; Deshmukh and Chavan, 2012; Dora, Van Goubergen, Molnar, Gellynck and Kumar, 2012; Kumar, Antony and Tiwari, 2011; Prasanna and Sekar, 2013; Timans *et al.*, 2012; Wessel and Burcher, 2004).

Particularly, the widespread applications of Six Sigma were possible due to the fact that organizations were able to articulate the benefits of Six Sigma presented in financial returns by linking process improvement with cost savings (Kwak and Anbari, 2006). This suggests it is applicable to all industry sectors (manufacturing, service and the public sector) and organization sizes.

From late 1990's, Six Sigma has expanded into a philosophy overlapping with dynamic leadership and a communications culture that is widespread so that it can be sustained in the long-term (Pande, Neumann and Cavanagh, 2000).

Six Sigma is also a business system for achieving and sustaining success through customer satisfaction, process management and sound data analysis incorporating elements from the work of many quality pioneers including

Juran, Crosby, Deming, Feigunbaum and Ishikawa, for virtually error-free business performance. To many employees of Motorola, GE, Honeywell, Bombardier, Black and Decker, ABB and Polaroid, Six Sigma is a company-wide transformation that has helped them to become very successful (Caulcutt, 2001).

However, Bhote (2003) notes that Six Sigma needs further enhancing, suggesting that when Six Sigma moved into business practice it became diluted and distorted. Bhote, who was Motorola University's emeritus worldwide consultant, suggested that Six Sigma needs to be improved to overcome the mediocrity of the traditional Six Sigma practices suggesting that it needed to be linked to strategic principles and best practice of the business for competitive advantage in the long-term.

Harry (1998) introduced the concept of a Six Sigma practitioner known as either a Master Black Belt, Black Belt, Green Belt or Yellow Belt. All are trained at various levels of proficiency in the application of the Six Sigma methodology. The Master Black Belt is usually the company facilitator, strategist and in-house trainer, the Black Belt is usually the technical and project leader and in-house trainer, the Green Belts are usually the project team members and the Yellow Belts can be data analysts. Generally Black Belts and Master Black Belts were employed in larger organizations and did not appear that often in SME's (Antony *et al.*, 2005).

Large organizations would have all these levels but SME's may be restricted to just one or more Black Belt and/or a number of Green Belts. Training at all levels except at the Master level generally is done internally or through external providers like Quality Certification bodies, for example the American Society for Quality (ASQ, 2012).

The methodology for Six Sigma was developed by Harry (1998) and enhanced by GE (Henderson and Evans, 2000). The phases of the methodology are represented by DMAIC or Define-Measure-Analyze-Improve-Control. Phases of the DMAIC methodology appear to be closely aligned to Deming's Plan-Do-Check-Act continuous improvement cycle (Bhuiyan and Baghel, 2005). The tools and techniques used within the phases vary depending on the project and availability of data but the intent behind each phase is common.

As an example, Pyzdek (2003a) suggests the five phases can be represented as in Table 2.1.

| | |
|---|---|
| **D** | **Define** the strategic goals at the top level (e.g. higher ROI, market share), increase the throughput of a production department at the operational level and to reduce the defect level and increase throughput at the project level; apply methods to identify potential projects |
| **M** | **Measure** the existing system. Establish valid and reliable metrics to help monitor progress towards the goals defined at the previous step. Begin by determining the current baseline. Use exploratory and descriptive data analysis to help understand the data. |
| **A** | **Analyze** the system to identify ways to eliminate the gap between the current performance of the system or process and the desired goal. Apply statistical tools to guide the analysis. |
| **I** | **Improve** the system. Be creative in finding new ways to do things better, cheaper, or faster. Use project management and other planning and management tools to implement the new approach. Use statistical methods to validate the improvement. |
| **C** | **Control** the new system. Institutionalize the improved system by modifying systems, documentation and other management systems. Documentation systems such as ISO 9000 can be utilized to assure control. |

Table 2.1: Phases of DMAIC, source Pyzdek (2003a)

A variation of the DMAIC methodology has also been applied in research and development when there is need to design a new process and are represented by the phases DMADV - Define, Measure, Analyze, Design, Verify (Pyzdek, 2003a) or by the phases IDDOV – Identify, Design & Develop, Optimize, Verify & Validate.

An example of these phases are provided by Mitra (2004) in Table 2.2. IDDOV and DMADV are sometimes captured under the banner of DFSS (Design for Six

Sigma) and have also been discussed in the books and articles by Stamatis (2003), Brue (2003) and Chowdhury (2003). There is limited

| Phase | Steps |
|---|---|
| **Identify** | Establish business case [Supplier, Inputs, Processes, Outputs, Customer]; Project Planning/Management [Establish milestones]; Preliminary cost/benefit analysis; Determine critical customer needs i.e. Voice of the customer |
| **Design & Develop** | Develop concepts, problem solving, Brainstorming, Benchmarking; Evaluate alternative designs; Analyze potential problems with selected designs, FMEA's; Design of experiments, Design for manufacturability, Supplier quality |
| **Optimize** | Introduction of robust design/taguchi concept; Tolerance design |
| **Verify and Validate** | Verify the design, Prototype build-test-fix, Conduct pilot production run; Validate, Assess performance, failure modes, reliability risks; Establish process controls, Error proofing, visual controls; Cost/benefit analysis and Future improvements |

Table 2.2: IDDOV phases, source Mitra (2004)

According to Harry and Schroeder (2000) when a company is at five sigma, that is 233 defects per million opportunities, assuming the standard process shift, they can only move to Six Sigma by re-designing their processes making use of IDDOV. IDDOV is often used when the existing processes do not satisfy the customers or are not able to achieve strategic business objectives (Eckes, 2000).

Clearly, Six Sigma first requires providing a conceptual definition and identifying an underlying theory (Schroeder, Linderman, Liedtke and Choo, 2008). Their research, using grounded theory approach, argues that although the tools and techniques in Six Sigma are strikingly similar to prior approaches to quality management, it provides an organizational structure not previously seen. Although this emergent structure for quality management helps organizations more rigorously control process improvement activities, while at the same time creating a context that enables problem exploration between disparate organizational members and provides benefits over prior approaches to quality management, it also creates new challenges for researchers and practitioners.

In summary, evidence in this section has shown that Six Sigma can be defined in many ways and the concepts, tools and techniques can vary considerably in each phase of DMAIC. Also, Six Sigma has short comings and has been met with varied success. It is argued thus far that TQM and Six Sigma are different but as philosophies they significantly overlap but there are common elements that create a successful deployment for each.

## 2.4 Lean

This section is included to link to the next section covering Lean Six Sigma.

Lean manufacturing originated from the Toyota Motor Corporation as the Toyota Production System (TPS) and increased in popularity after the 1973 energy crisis. Beginning in machining operations and expanding the scope accordingly, Taiichi Ohno, Toyota's CEO led the development of the Toyota Production System. Lean manufacturing or Lean thinking was eventually coined in 1990 and was a methodology that focuses on reducing cycle time and waste in processes (Womack and Jones, 1996).

Womack et al (1994) commented that Lean as the systematic removal of waste by all members of the organization from all areas of the value streams. The wastes of Lean are generally categorized as Transportation; Inventory; Motion; Waiting; Overproduction; Over-processing and Defects (Endsley, Magill and Marjorie, 2006).

According to McCurry and McIvor (2001) there are five principles of Lean, namely: Understanding customer value – only what customers value is important; Value stream analysis – to determine which processes add value to the customer; Flow – focusing on continuous flow rather than large batches; Pull – no work is performed unless requested; and Perfection – continual focus on reduction of all wastes.

The term 'Lean Enterprise' was used to broaden the scope of a Lean programme from manufacturing to embrace the enterprise or entire organization (Alukal, 2003). Lean is generally understood to represent a systematic approach to identifying and eliminating elements that do not add value to the process which strives for perfection and customer-driven pull of the process (Andersson *et al.*, 2006). According to Ferguson (2007), Lean is a continuous improvement philosophy and teaches people that success is achieved when the entire value stream improves, not when one discrete element of it does.

Lean strives to make organizations more competitive in the market by increasing efficiency, decreasing costs incurred due to elimination of non-value adding steps and inefficiencies in the processes (Motwani, 2003) as well as reducing cycle times (Sohal and Egglestone, 1994) and increasing profit for the organization (Claycomb, White and Prybutuk, 2001).

Despite the several success stories associated with the Lean concept, it has some shortcomings. The Lean organization may become very susceptible to the impact of changes. The leanness in itself leads to reduced flexibility and less ability to react to new conditions and circumstances (Dove, 1999). Just-in-time deliveries cause congestion in the supply chain, leading to delays, pollution, shortage of workers, etc. (Cusumano, 1994).

Again, it is clear that with Lean there have been both success stories and shortcomings. It is argued that there are underlying success factors with TQM, Six Sigma and Lean.

## 2.5 Lean Six Sigma

The evolution of Lean Six Sigma has taken place since maintaining high production rates and high quality, or producing less waste, simply does not address enough areas that require improvement (George, 2003). The evolution of Lean Six Sigma has been challenged by Maleyeff, Arnheiter and Venkateswaran (2012).

Smith (2003) comments that when Six Sigma and Lean production methodology run separately they will collide with each other and in contrast, a combination of Lean and Six Sigma will have a positive impact on employee morale, inspiring change in the workplace culture because teams see the results of their efforts put to work almost immediately.

Lean cannot bring a process under statistical control and Six Sigma alone cannot dramatically improve process speed or reduce invested capital. The fusion of the two helps organizations maximize their potential for improvement (Bhuiyan and Baghel, 2005).

A logical justification for blending Six Sigma with Lean is given by Devane (2004). He states that a pure Six Sigma approach lacks three desirable Lean characteristics:

1. No direct focus on improving the speed of a process
2. No direct attention to reduction in the amount of inventory investment
3. No quick financial gains due to the time required to learn and apply its methods and tools for data collection and analysis.

However, Devane (2004) further states that on the other hand, a pure Lean improvement effort has the following shortcomings:

1. Processes are not brought under statistical control
2. There is no focus on evaluating variations in measurement systems used for decisions
3. No process improvement practices link quality and advanced mathematical tools to diagnose process problems that remain once the obvious waste has been removed

When the differences between Lean and Six Sigma are recognized, returns can be maximized by knowing when Lean or Six Sigma is the right choice (Ferguson, 2007). This may create difficulty for inexperienced project leaders who may choose the wrong approach.

Comprehensive descriptions of Lean Six Sigma can be found in a number of articles (Arnheiter and Maleyeff, 2005; Pepper and Spedding, 2010; Snee, 2010; Souraj, Rahim and Carretero, 2010). While the term "Lean Six Sigma" is quite commonly used, the definition varies across different sources and does not mean the same thing. Many books on Lean Six Sigma just describe as DMAIC with the inclusion of Lean and Six Sigma, quality and statistical tools and therefore, there is not much difference to Six Sigma (Gershon and Rajashekharaiah, 2011). The actual tools and techniques used within the phases of applying the DMAIC methodology can vary depending on the type of process studied and the project problems that are encountered (Corbett, 2011). For example, when the problem is time reduction focused, then Lean would predominantly be used and if the problem is concerned with accuracy of a process compared to the target then more statistical tools (or Six Sigma tools in effect) would be used.

There are a number of examples of manufacturing companies implementing a combined effort of Lean and Six Sigma. An early example, starting in 1997, was by an aircraft-engine-controls firm, BAE Systems Controls, in Fort Wayne, Indiana where they blended Lean with Six Sigma quality tools (Sheridan, 2000).

Another early innovator combining Lean and Six Sigma was Maytag Corporation. It implemented Lean Six Sigma in 1999 and designed a new production line using the concepts of Lean and Six Sigma (DubaiQualityGroup, 2003). Lean Six Sigma has been implemented at Northrop Grumman, an Aerospace Company. They had already begun to implement Lean when they embarked on Six Sigma. They integrated the Workout events (a problem-solving process developed at General Electric) with the Lean methods and Kaizen events (McIlroy and Silverstein, 2002).

Lockheed Martin Aeronautical Systems reduced costs, improved competitiveness, customer satisfaction and the first-time quality of all its manufactured goods. They had separate Lean and Six Sigma projects, depending on the objective of the project and the problem that needed to be solved (Kandebo, 1999).

In summary, it is not clear whether Lean Six Sigma has been created because the previous initiatives failed or it is a logical extension of the DMAIC model. Further, it appears that Lean Six Sigma is DMAIC with Lean added at various phases depending on the type of problem.

## 2.6 Comparison of TQM, Lean, Six Sigma and Lean Six Sigma

According to Hendricks and Singhal (1997), Six Sigma was the centerpiece of Motorola's TQM initiative but it is now being sold as something quite unique and different from TQM. Klefsjo, Wiklund, and Edgeman (2001) have suggested that the Six Sigma methodology (DMAIC) has evolved from TQM and Deming's continuous improvement cycle (Plan-Do-Measure-Act). This is supported by Pyzdek (2001) who suggests that Six Sigma also overcomes the short-comings of TQM by focusing on the business as a whole system rather than just quality, stretched goals (3.4 defects per million opportunities) rather than minimum standards for quality and an infrastructure of change agents rather than no infrastructure to support business improvement.

Hoerl *et al* (2004) suggests that there is a significant future for Six Sigma compared to TQM which has died away due to the following reasons:

- There is a continuing evolution both in terms of tools and deployment strategies
- Significant growth in new areas like healthcare and financial services
- Further applications in research and development, for example Design for Six Sigma
- Integration with quality management systems and Lean operations

Nevertheless, Goedert (2004) has suggested that some organizations are hesitant to embrace Six Sigma fearing it is just a repackaged version of past "failed quality programs like TQM". The comment that Six Sigma needs further enhancing because when Six Sigma moved into business practice it became diluted and distorted cannot be ignored (Bhote, 2003).

In the interview with Mikel Harry by Rath and Strong (2006), it is recorded that when an organization adopts TQM, it becomes involved in the business of doing quality and when it adopts Six Sigma, the organization is concerned about the quality of business. In a nutshell, TQM is a defect-focused quality improvement initiative whereas Six Sigma is an economics based strategic business management system.

Harry suggests that Six Sigma did not start off that way but it evolved that way and that Six Sigma uses the standard tools that are part of a TQM program.

In the interview with Joseph Juran by Rath and Strong (2006), it is recorded that Six Sigma is not different from other quality innovations except for two notable features. One is that it has captured the interest of many quality executives and the other is that the training structure is significantly different in which Black Belts and Green Belts facilitate the Six Sigma projects.

Despite the differences TQM and Six Sigma place on profit improvement, the two philosophies do have many common themes (Näslund, 2008). Manufacturing and engineering operations have shown Six Sigma to be a successful strategy for reducing errors and improving efficiencies, but there must be some basic TQM principles in Six Sigma. Revere and Black (2003) demonstrate that integrating the Six Sigma metrics with TQM also provides a measure of comparability that can be used to facilitate process improvement.

It appears that as a management philosophy, Six Sigma is analogous to TQM (Goeke and Offodile, 2005). A quality management business strategy relies on statistical tools and specifically designed processes and methods to achieve measurable goals, such as increasing efficiency and productivity and enhancing products and processes. This strategy can be used as a leadership approach, philosophy and change methodology (Banuelas and Antony, 2002).

TQM was being used as the primary quality initiative by the manufacturing organizations during the 1980's and 1990's, but with TQM there is no clear way of prioritizing which quality project should receive the highest priority, and projects are carried out irrespective of the cost to the corporation. This was one of the reasons for the advent of Six Sigma which is quite explicit about the financial benefits expected from each and every effort (Bhuiyan and Baghel, 2005).

Dahlgaard *et al* (2006) compares the Lean production philosophy with the Six Sigma quality process and the principles of TQM. The author discusses how to build the necessary company culture for having success with any of these principles and management philosophies. It is shown that the Lean production philosophy and the Six Sigma steps are essentially the same and both have developed from the same root - the Japanese TQM practices.

In particular, Dahlgaard *et al* (2006) further suggests that the DMAIC improvement process in Six Sigma can be regarded as a short version of the quality story, which was developed in Japan in the 1960s as a standard for QC Circle presentations. The roadmaps of Lean production and Six Sigma quality are examples of new alternative TQM roadmaps. The author concludes that, especially with Lean production and Six Sigma, there seems to be too much focus on training people in tools and techniques and at the same time too little focus on understanding the human factor, i.e. how to build the right company culture.

Antony (2009) interviewed a number of leading academics and practitioners about Six Sigma and TQM and the interviewees noted some clear and major differences. The similarities between TQM and Lean Six Sigma include the overlap of the use of quality and statistical tools and perhaps also the same philosophy of excellence in customer service and the need to develop a corporate culture to allow improvements to be sustained.

The differences are in the infrastructure (Antony, 2004b) and training of Six Sigma and Lean experts (Stamatis, 2003) and their full-time involvement in DMAIC projects using cross-functional teams (Thawani, 2004) and Kaizen-type improvements respectively (Stamatis, 2003). Another difference for Lean Six Sigma over TQM (and perhaps Lean) is the emphasis on the importance of data and decision making based on facts and data rather than assumptions and hunches (Antony, 2004b).

What seems to be missing from the research literature is the examination of a systemic approach to organizational change and improvement that can be sustained (Näslund, 2008).

It is not clear in the literature whether companies are deploying Lean Six Sigma because the previous initiatives like Lean, Six Sigma and TQM failed and it will result in better outcomes or it is a natural progression to adopt a new innovation and a new technique. With respect to a philosophy, there appears to be a significant overlap between these initiatives. This suggests the need to examine the critical factors common between Lean Six Sigma and TQM that an organization needs to support for a successful deployment. This is examined in research question 5.

## 2.7 Key drivers and success measures of a Lean Six Sigma deployment

### 2.7.1 Introduction

This section provides a review of the literature on the key drivers and success measures of Lean Six Sigma and makes reference to the drivers and success measures of Six Sigma, TQM and Lean.

### 2.7.2 Key drivers

Profitability has been the driver of many quality improvement initiatives (Hojberg, 2010; Klein, 2007; McCarthy, 2009; Moad, 2007; Tanco, 2012). Profitability will be achieved if an organization reaches a level of competence by supporting a number of critical success factors. This is demonstrated by Grahn (1995) for TQM in which many organizations need to manage the balance between people quality, entrepreneurial and innovation quality, information quality, planning/decision quality and process/execution quality and also by Pande *et al* (2000) who suggests that Six Sigma must be accompanied by a creative thinking and dynamic leadership and a communications culture that is widespread so that it can be sustained in the long-term.

Another driver for many organizations is the need to pay greater attention to their human capital by involving employees in improvement projects. Failure to do so will cause these companies to lose their competitive advantage (Fleming and Asplund, 2007).

Dolich *et al* (1994) suggest that key drivers for the deployment of any continuous improvement effort are to: provide education and training in quality for all employees; schedule periodic quality reviews with direct reports; develop and review strategic quality plans and objectives on an ongoing basis; clarify and set specific responsibilities for quality; monitor and continually improve the defect and error rate of internal processes and systems; and monitor and continually improve the level of customer satisfaction.

Key drivers for Six Sigma have been represented by tangible measures such as higher profitability, market share, increased savings and margins, reduction in rework through lower operational costs and intangible success measures like improved culture, customer satisfaction and employee engagement (Caldwell, 2006; Motwani, Kumar and Antony, 2004; O'Rourke, 2005).

The key drivers of Lean are customer value, optimising the value stream, focusing on flow and pull, empowerment of the workforce and perfection (Kennedy, Owens-Jackson, Burney and Schoon, 2007). There is also a focus on productivity in Lean by minimizing the number of process steps and standardizing processes to minimize changeover time as the key drivers of efficient throughput (Munroe, 2008).

There are many drivers for introducing Lean techniques in an organization, as it may contribute substantially to cutting costs and providing competitive advantages. According to a survey (NIST, 2000), of 40 companies that had deployed Lean manufacturing, typical improvements are visible in three areas.

These improvement areas include: operational improvements (reduction of lead time, increase in productivity, reduction in work-in-process inventory, etc.), administrative improvements (reduction in order processing errors, streamlining of customer service functions so that customers are no longer placed on hold, etc.) and strategic improvements (reduced costs, etc.).

Specifically in aerospace industries, Lean has been deployed to focus on long-term initiatives including: corporate-wide work teams that are fully accountable for their work and that all have the metrics they need to measure their performance; creating a culture that encourages employees to propose better ways of meeting performance goals; focusing on core competencies and reducing the company's cost structure (Crute, Ward, Brown and Graves, 2003).

The reasons for deploying Lean Six Sigma often include poor financial performance, diminishing customer satisfaction, increased competition or the existence of a burning platform/problem area (Duarte, 2011). Other drivers of Lean Six Sigma are to generate cash in difficult economic times, develop a data-based process management systems and use improvement as a leadership development tool (Snee, 2010).

According to George (2003), a driver of Lean Six Sigma is to maximize shareholders value by achieving the fastest rate of improvement in customer satisfaction, cost, quality, process speed and invested capital.

Lean Six Sigma has been applied in financial service organizations to improve operational efficiency and effectiveness (De Koning, De Mast, Does, Vermaat and Simons, 2008) and this seems to be similar to all other industry sector applications including manufacturing, services and government. In the service sector, reduction of cycle time is one of the key drivers (Ray and Boby, 2011).

The healthcare industry is constantly concerned about how to better streamline the services they provide to deliver better patient care with less waste of resources (Antony, 2008b). In a newspaper article (Targeted News Service, 2009), it was reported that hospitals across the United States are beginning to embrace Lean and Six Sigma business management strategies in attempts to reduce costs and improve productivity.

In the Information Technology and Telecommunications Sector, the driver of Lean Six Sigma is to improve its service quality and efficiency with the aim of gaining market share (Li, Wu, Yen and Lee, 2011).

An application of Lean Six Sigma can be seen in the military sector where the focus is on upgrading both heavy and light combat vehicles and their components and individual and crew-served weapons, land combat missiles and small arms (Raulerson and Sparks, 2006). The bottom-line is a process that continually produces a high-quality product, on time and within or below established budgets, so that equipment can be returned to the war-fighter quickly and at the lowest possible cost to the taxpayer.

The above demonstrates that the key drivers of Lean Six Sigma (and Lean and Six Sigma) are at two levels – one level relating to operational drivers like reduced cycle time, reduced costs, savings, process efficiency and improved quality and at an organizational level like competitive advantage, higher profitability, increased market share and improved customer satisfaction.

### 2.7.3 Success Measures

The success of Lean Six Sigma has been measured at either an operational or organizational level.

At the operational level, Lean Six Sigma uses projects which have metrics like overall quality, process efficiency, responsiveness and cost reduction (Shah, Chandrasekaran and Linderman, 2008). This is consistent with quality, delivery, flexibility and cost measures frequently used in the past Operations Management literature (Ward and Duray, 2000). The impact of Lean Six Sigma at Lockheed Martin Aeronautical Systems resulted in reduced costs, improved competitiveness, customer satisfaction and the first-time quality of all its manufactured goods (Kandebo, 1999).

These operational measures are also consistent with the latest International Standard on Six Sigma (ISO13053, 2011) in which there are a number of success measures appropriate for Six Sigma (with Lean covered) including the following:

- Product return rate (Overall quality)
- Number of problem reports (Overall quality)
- On time delivery (Responsiveness, process efficiency)
- Cost of poor quality (Overall quality, cost reduction)

At an organizational level, savings is a measure of success of Lean Six Sigma since in many large US companies, savings have been suggested to be a result of performance improvements in on-time delivery, defect rate reduction and productivity gains in manufacturing and service (Pyzdek, 2003a). Other measures noted by Pyzdek (2003a) have included improved market share, improved cycle times, higher employee and customer satisfaction, better employee and customer loyalty and employee and community citizenship which are a mixture of tangible and intangible measures at an organizational level.

The Xerox organization defined success for their Six Sigma program as increasing profits, reducing costs, business velocity and increased customer satisfaction whilst another large US business used improvement metrics in quality, productivity, cross functional collaboration and employee satisfaction as the success measure (O'Rourke, 2005). Success for Six Sigma in GE was measured by increased operating profit margins, reduced cycle time, increased employee productivity, improved customer satisfaction and minimized production defects (Caulcutt, 2001). Again, these are mixtures of operational and organizational measures.

Lockheed Martin Aeronautical Systems measured success of their combined effort of Lean and Six Sigma by reduced costs, improved competitiveness, customer satisfaction and the first time quality of all its manufactured goods (Kandebo, 1999). These measures are again mixtures of operational and organizational measures.

Leipold (2007) has reported success of Lean Six Sigma in the US Army in which leaders anticipate reaching a $2 billion savings mark. Projects included more efficient meal scheduling, streamline the communication process across the chain of command, reducing waste and speeding up the information management process, improving the process of recruitment and fuel-recycling initiatives. Again, these are mixtures of operational and organizational measures.

However, organizations may improve cycle time and process capability but may not yield bottom-line savings. Again, this creates a varied impression of the success of Lean Six Sigma according to which indicator is selected. For example, if the success measure is increased savings then Six Sigma has been shown to be effective (Pande *et al.*, 2000) but when stock price is the indicator, then it is not so clear (Goh, Low, Tsui and Xie, 2003).

When corporate competitiveness is the measure, Six Sigma has been shown to be successful (Lee and Choi, 2006). Pyzdek (2004) suggests, during a chat room discussion on when a Six Sigma project shows bottom-line savings, there is no guarantee that the organization will be successful in the market place.

According Goh and Xie (1994), improved process capability will mean that defect rates are lower and customers are satisfied and sales are likely to grow. Also, Lee et al (2006) conclude that Six Sigma activities at Samsung enhanced process innovation and improved quality which finally resulted in corporate competitiveness.

According to Sony and Naik (2012), there is a positive relationship between Six Sigma and organizational learning. It also confirms that Six Sigma role structure and Six Sigma focus on metrics contributes positively to organizational innovation. However, Six Sigma structured improvement procedure was found to be negatively related to organizational innovation, thus contributing to Six Sigma-Innovation Paradox.

For TQM, Berger (1999) proposes that key drivers of TQM are reduced lead time, improved quality and reduced cost which should result in savings and improved customer satisfaction and competitiveness.

Also for TQM, Seow (1997) suggests that the key drivers for TQM using five case studies in Malaysia are to improve productivity, improve the quality of products and services and enhance competitive leverage but concludes that the focus of TQM was in the short-term only because the studied organizations devoted attention to the product and at best the process and paid lip service to people issues and recorded failings in supporting organizational cultural change.

The studied organizations were on their way to a "learning organization" (Senge, 1990) but the best of these organizations was a long way from the ultimate goal. This was because there was significant movement of key technical people between organizations and the quality experts were only involved for a short time in one organization moving fairly quickly to another.

Organizational level measures tend to be for the long-term measures whereas operational level measures used in projects tend to be measures for the short-term unless there is some level of maturity to ensure that the measure is continually improved.

Also, measures of success at the operational level through projects, for example reduced cycle time may not necessarily lead to success at an organizational level, for example competitive advantage which would be a driver of the organization in the long-term.

Table 2.3 summarizes the key drivers and success measures across TQM, Lean, Six Sigma and Lean Six Sigma based on the review of the literature presented in this section. Similar key drivers and success measures apply across all the quality initiatives. What is missed out for Lean and Six Sigma is picked up by Lean Six Sigma. Shareholder value for TQM was never demonstrated.

| Key driver & Success Measure | Operational or Organizational | TQM | Lean | Six Sigma | Lean Six Sigma |
|---|---|---|---|---|---|
| Profitability or Savings | Organizational | √ | √ | √ | √ |
| Competitive Advantage | Organizational | √ | √ | √ | √ |
| Cost reduction | Operational | √ | √ | √ | √ |
| Customer Satisfaction | Organizational | √ | √ | √ | √ |
| Maximize Shareholder Value | Organizational | | √ | √ | √ |
| Process Efficiency | Operational | | √ | | √ |
| Process Quality | Operational | √ | | √ | √ |
| Productivity | Operational | √ | √ | | √ |
| Market Share | Organizational | √ | √ | √ | √ |

Table 2.3: Key drivers and Success Measures for TQM, Lean, Six Sigma and Lean Six Sigma

In the next section, the concept of "maturity" is discussed as a long-term measure of success. Organizations can be mature and the operations can be mature through project improvements being undertaken on a regular basis.

### 2.7.4 Maturity of a Lean Six Sigma deployment

Using project success is one way to measure the success of a Lean Sigma program. Various authors (Duarte, 2011; Moosa and Sajid, 2010; Olson, 2010; Raje, 2009) have suggested that long-term success is also a necessary measure that is; if the Lean Six Sigma deployment is mature. An example of this maturity for Lean Six Sigma was shown in the Health sector in which healthcare systems in the US are still in the 'infancy stage' when it comes to using these vital cost-cutting tools (Targeted News Service, 2009).

Selecting projects strategically (Pyzdek and Keller, 2010) presents challenges for many companies (Kornfeld and Kara, 2013). This paper reveals that there is significant practitioner dissatisfaction with the approaches used; a gap between strategy formulation and portfolio generation; and those organizations generally use subjective or unstructured approaches and seldom apply the approaches that are advocated in the literature. The practical implications in this work suggested that there needs to be an improved linkage from strategy to portfolio ought to lead to better project outcomes and longevity of the methodology. This suggests a maturity measure would be useful.

This concept of maturity is similar to that developed by Edgeman (2013) for Sustainable Enterprise Excellence (SEE), which is a model defined and developed through integration and expansion of business excellence modeling and sustainability thought. The key elements of SEE are identified from various business excellence and sustainability reporting sources, including the Global Reporting Initiative, the UN Global Compact 10 Principles, and criteria of the European Quality Award and MBNQA.

The success in most Lean Six Sigma programs have a short-term focus since there is little or no organizational learning that results from the project improvements (Wiklund and Wiklund, 2002). What seems to be missing, however, is the need for a systemic approach to organizational change and improvement (Näslund, 2008). These comments tend to suggest that some organizations get to early stages of a mature deployment fairly quickly but take time to get to an organization that has had a "Culture Transformation" (Duarte, 2011; Moosa and Sajid, 2010; Olson, 2010; Raje, 2009). Where there is a culture transformation there is sustainable practice.

The Six Sigma standard (ISO13053, 2011) suggests a maturity level for the deployment of Six Sigma which also includes Lean as part of the Six Sigma philosophy. In this standard, it makes reference to five maturity levels for process improvement for an organization. The initial level is where there is no description of any process in the organisation; the second level is where the process to respond to the customer has been formalised; the third level is where processes of the whole organisation are defined; the fourth level is where all the processes of the third level are quantitatively managed with indicators and finally level five is where the processes can be optimised with the use of indicators.

Maturity of a Six Sigma deployment using five levels has been also developed by Raje (2009). The levels are - the launch, Early Success, Scale Replication, Institutionalization and Culture Transformation.

The "Launch" is the starting point wherein an initial few visionaries in the organization launch Six Sigma, training is initiated and projects begin. The "Early Success" is where the initial projects are yielding results and early successes are being achieved. The "Scale Replication" stage is where the early success has led to other parts of the organization buying into Six Sigma and a broader launch of projects is underway. The next stage, "Institutionalization", is where projects are yielding broad based financial impact throughout many parts of the organization. The last stage, "Culture Transformation", is where Six Sigma is part of the organizational DNA, financial impact is sustained and the Six Sigma culture is pervasive – even beyond the Six Sigma practitioners and beyond the organization's boundaries.

According to Moosa *et al* (2010), there are usually three distinct states in getting maturity of Six Sigma: (1) immature state, the starting state where it may or may not be integrated fully with other organisational functions; (2) amateur state, that is the state where people are at the basic level of know-how and lack experience; and (3) mature state, where Six Sigma gets robust and becomes part of the organisational culture.

If these first two states are successful, the maturity starts. As these practices become part of the routines and habits of people, the need for reinforcement is minimised. New habits improve the overall organisational culture. Management usually gets frustrated in the first or second phase where a lot of teething problems arise. Many abandon it at this pre-mature stage. This is a pre-mature management. If the rate of learning of Six Sigma teams is slow in the first two phases of the project, the maturity is never achieved and people also tend to abandon it.

Goh and Xie (2004) suggest that to make Six Sigma relevant and useful in the long-term, business leaders should incorporate, firstly a systems perspective, which helps for an integrated approach avoiding local sub-optimization, as well as providing macro-level assessments and reviews and secondly, strategically, with a substantial component of scenario planning aimed at anticipating changes, managing dynamic market demands, predicting novel lifestyles, seizing technological innovations, even promoting creativity and entrepreneurship. Accordingly, these two additional features add to the DMAIC methodology to allow a company to move to long-term excellence.

He (2009) uses the Malcolm Baldrige National Quality Award (MBNQA) to define the program maturity for Six Sigma. The MBNQA criteria categories are: Leadership; Strategic Planning; Customer Focus; Workforce focus; Operations Focus and Results - which, in a sense, define an organization's competency.

Therefore, it makes sense to measure the sustainability of a Lean Six Sigma deployment using two success measures - (1) the success of projects in relation to overall quality, process efficiency, responsiveness and cost etc. and (2) the maturity level of the deployment.

This suggests that a combination of project success and a mature deployment may lead to organizational success. These two measures of success form the output (response) variables in a model developed in fieldwork phase 4 (Chapter 7) to gain further insight into Lean Six Sigma sustainable deployment.

### 2.7.5 Project Success, Maturity and Key Drivers

To visually link the points made in sections 2.6.2 to 2.6.4, Figure 2.1 represents a possible relationship between Project Success measures and Maturity of a Lean Six Sigma deployment with Key Drivers or measures at the organizational level.

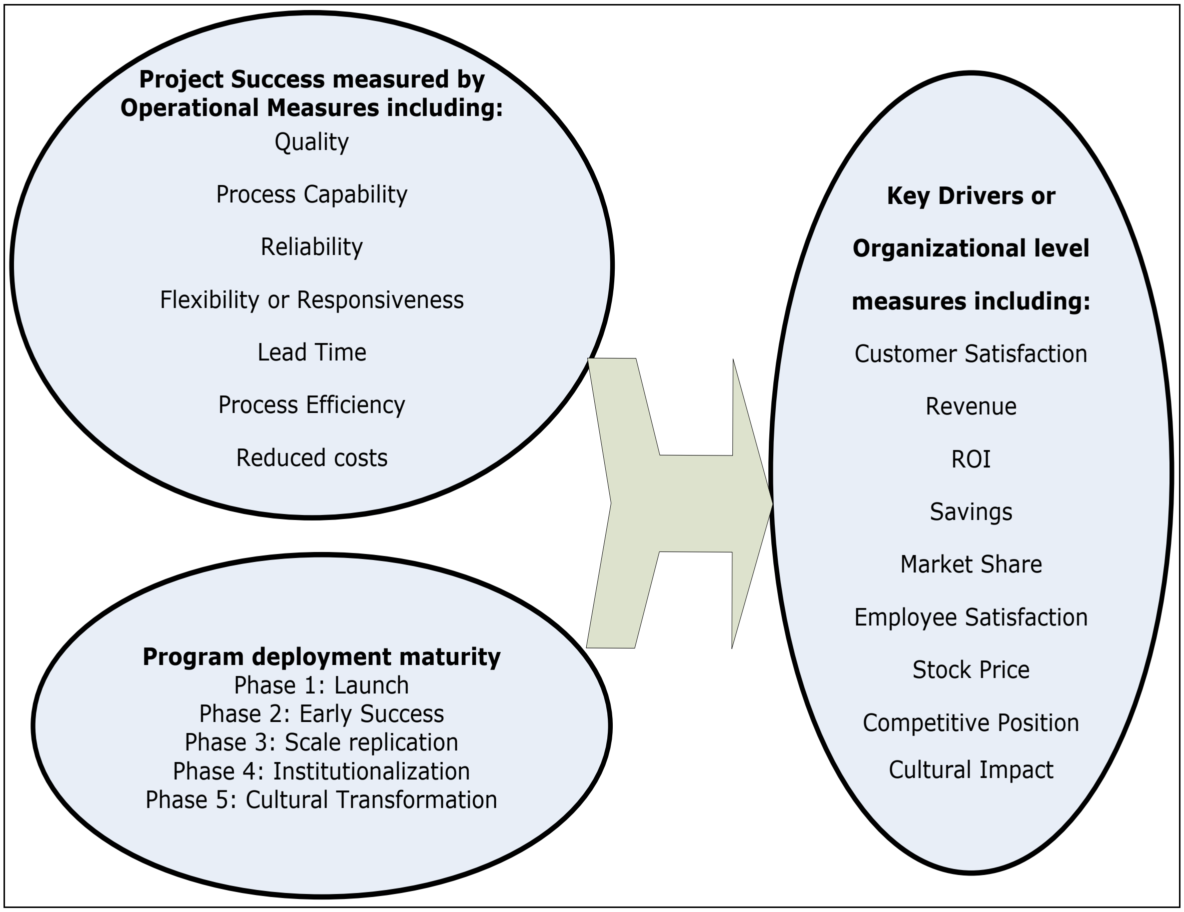


Figure 2.1: Link between Project Success (Operational measures), Maturity level and LSS Program Success (Organizational measures)

### 2.7.6 Development of Research Question 1

From the above discussion, the key drivers of Lean Six Sigma are at two levels – one level relating to operational drivers such as reduced cycle time, reduced costs, improved process efficiency and improved quality resulting from project work and at another level relating organizational drivers such as higher profitability, increased market share and improved customer satisfaction.

There appears to be contradictory evidence that the focus on measures at an operational level will lead to success at an organizational level. The assumption by many organizations appears to be that a focus on the operational drivers will lead to success at the organizational level or success at the operational level is "good enough". However, this may not be sustainable.

A clear definition of performance is critical to agree and set before an assessment is made of the success of the deployment. For example, an organization could fail on increasing market share from a Lean Six Sigma program but have a successful project from the point of view of better quality and responsiveness.

It is not clear whether companies are deploying Lean Six Sigma because the previous initiatives failed and it will result in better outcomes or it is a natural progression to adopt a new innovation and a new technique.

It is not clear that the drivers to deploy Lean Six Sigma are different to previous quality improvement initiatives. For example, TQM was introduced in the 1980's to create a culture of continuous improvement, improve quality and enhance an organization's competitive advantage and it is not clear if Lean Six Sigma has been deployed to deliver something else or the same, since Total Quality Management was suggested to have failed.

It is clear that writers on Lean Six Sigma believe that it has been successful but success seems to vary according to the performance or success measure used. For example, if success is defined as higher market share then Lean Six Sigma may not be deemed successful but if success is defined as process cost reduction or savings due to better delivery performance and process capability then it may be deemed successful.

The literature covers the concept of a "mature" deployment of Six Sigma which is another way of measuring success apart from success from improvement projects. An organization which has a high level of maturity and where projects are successful is one that has been transformed culturally to an environment of sustainable continuous improvement.

Success of a Lean Six Sigma deployment can include project success and projects are measured at an operational level by metrics such as Quality, Responsiveness, Cost Reduction and Schedule Adherence. Success, however, should include a measure of the level of maturity of the Lean Six Sigma deployment. Organizational level measures tend to be long-term measures whereas operational level measures used in projects tend to be measures for the short-term unless there is some level of maturity of the organization to ensure that the measure can be continually improved.

To achieve sustainable improvement organizations must have long-term objectives like higher market share and improved customer satisfaction and to achieve this, these organizations must drive towards ongoing project success (measured by, for example, reduction in rework and process efficiency) and a mature deployment (the level of maturity of the deployment).

Based on the above discussion and the literature review in sections 2.6.2 to 2.6.5 where a number of issues and contradictions are raised relating to drivers and success measures for TQM, Six Sigma, Lean and Lean Six Sigma, the first research question has been developed, namely what are the key drivers and success measures of a Lean Six Sigma deployment?

In fieldwork phase 1 (Chapter 4), key drivers of Lean Six Sigma are derived for a number of organizations in manufacturing and service and are presented to provide further insights into the concept of success. The use of maturity as a measure of success is examined in fieldwork phase 4 (Chapter 7) in order to provide insights and/or challenge current theory and practice.

## 2.8 Deployment Strategies and Models for Lean Six Sigma

### 2.8.1 Introduction

In this section, a review of the literature on deployment strategies and models used for Lean Six Sigma is presented and where appropriate comments are made for TQM, Lean and Six Sigma.

### 2.8.2 Deployment strategies

Generally, many organizations start improvement efforts by first considering the criteria or characteristics of a best practice model they plan to follow. Most skilled organizational improvement practitioners would argue that you want a whole system model, similar to the approach by Deming (Snee, 2010). One proven whole system model is the Malcolm Baldrige National Quality Award's improvement model (Werner, 2007). One also needs to use a robust top-down process to identify the right projects (Gates, 2007; Shanmugam, 2007).

According to Gusman, Lim and Siti (2013) using empirical evidence, Lean practices should be implemented holistically (across the whole organization) and will have a positive and significant impact on both operations performance and business performance.

Deployment strategies for Six Sigma have been widely discussed (Byrne, 2003; Challener, 2001; Knowles, Johnson and Warwood, 2004; Motwani *et al.*, 2004; Revere and Black, 2003; Yacovone, 2007). For example, strategies for Six Sigma have included incorporating Six Sigma with current TQM efforts to minimize disruption (Revere and Black, 2003); a project approach rather than a company-wide approach (Knowles *et al.*, 2004); aligning people, process and technology in the supply chain (Yacovone, 2007); the need for active support and engagement of all business process owners in Six Sigma project implementation down-the-line must be enlisted (Byrne, 2003) and Six Sigma being a customer-focused approach to business that provides an overall framework for quality management (Motwani *et al.*, 2004).

For example, Motwani *et al* (2004) pose a theoretical model for a Six Sigma implementation based on a case study in Dow Chemical in the US. The theoretical model is defined as collective plans, activities and events designed to ensure products, processes and services will satisfy customer needs and more specifically is a customer-focused approach to business that provides an overall framework for quality management.

For Lean Six Sigma, a deployment approach has been to align the deployment with the strategy of the organization (Linderman, Schroeder, Zaheer and Choo, 2003; Snee and Rodebaugh Jr, 2002). The strategy typically includes a plan that addresses the high level goals of the organization - including sales growth, earnings per share, profit, or return on invested capital - each of which drives at satisfying the shareholder (Banuelas, Tennant, Tuersley and

Tang, 2006). The strategic objectives are then broken down into performance success measures at the operational level.

Duarte (2011) offers a deployment strategy as being implemented over a life cycle. The phases are:

- Phase 1: Pilot or proof of concept phase
- Phase 2: Focused deployment within a specific area of the business
- Phase 3: Full-scale education resulting in mass education across the organization
- Phase 4: Maintain and sustain Lean Six Sigma program critical mass.

The strategy includes a pilot or proof-of-concept phase and ends with a company-wide Lean Six Sigma deployment. Very specific business problems are addressed in the pilot phase to demonstrate the usefulness of the methodology and to gain buy-in. As the deployment progresses, larger investments are made in infrastructure, education and training of Yellow Belts, Green Belts, Black Belts and Master Black Belts. In addition, as the deployment progresses, the compositions of the projects tend to change, and the focus is more end-to-end. Eventually, Lean Six Sigma becomes a way of life as the organization reaches critical mass with its training (similar to a level of maturity as noted in section 2.6.4).

In an attempt to overcome the (suggested) shortfalls in the Lean approach and the Six Sigma approach, De Koning *et al* (2008) have proposed an integrated deployment framework for Lean Six Sigma that consists of the following elements:

- A structured approach based on Six Sigma organisational mechanisms, i.e. task force deployment strategy with Black Belts, Green Belts, etc.
- Project-based deployment where a project aims at a chronic problem scheduled for solution (Juran, 1989)
- Organisational competency development through the training of project champions, Black Belts, etc. in a curriculum of Six Sigma and Lean components

- Organisational anchoring of solutions and guarding against backsliding by standardization of new processes and imposition of process controls
- The linking of strategy with project selection by translating strategic objectives into performance indicators and tactical goals, by using these as a basis for project selection and to help secure an alignment of projects with the overall organisational strategy (Pyzdek and Keller, 2010).

Organizations with a project-based deployment can focus on essentially three types of projects (Mader, 2008):

1. Implementing Lean-type project improvements
2. Solving complex problems using advanced statistical analysis
3. Solving problems with less advanced statistical tools

Duarte (2011) suggests three types of deployment:

1. Top-Down, company-wide
2. Partial, business unit deployment
3. Process-focused deployment

A Top-Down, company-wide deployment is driven by strong governance (Gates, 2007). GE was a good example of a top-down, company-wide approach in which there is quick wins and many projects resulting in significant return-on-investment (ROI) over many years. This meant however, large investment, high risk and complex change management.

A partial deployment in a business unit is one in which there is reduced complexity and scope, easier change management and localised success where the whole organization may not be ready for the deployment. It would take a longer time to deploy and the ROI would be smaller (Duarte, 2011). A process- focused deployment would involve quick wins and addresses a burning platform but has a narrow scope and the ROI is small and it may sub-optimize the supply chain (Duarte, 2011).

In deploying Lean Six Sigma, some organizations are still leveraging off the previous quality and continuous improvement initiatives like Business Process Reengineering and TQM (Andersson *et al.*, 2006; Cheng, 2009; Dahlgaard and Dahlgaard-Park, 2006; Furterer and Elshennawy, 2005; Zu, Robbins and Fredendall, 2010). This suggests that there are practices within previous quality initiatives like TQM that are fundamental to success or sustainable practice that also apply within a Lean Six Sigma deployment. This is addressed in section 2.10 with respect to developing the common factors critical to success for both Lean Six Sigma and TQM.

### 2.8.3 Deployment Models

A Lean Six Sigma deployment involves projects following the Define-Measure-Analyze-Improve-Control (DMAIC) methodology. The use of different tools for each phase of DMAIC can vary between Lean, simple statistical, advanced statistical and quality tools as appropriate. The ISO standard on Six Sigma (which incorporates Lean) suggests a set of best practice tools for each phase of DMAIC (ISO13053, 2011).

The many tools in the Lean tool set help to eliminate waste and organize and simplify the work processes and the many tools used within a Six Sigma context are essentially statistical and quality-related but are certainly not new. The appropriate tools for each phase of DMAIC have been documented well for Six Sigma but there is limited academic research for Lean Six Sigma. Bendell (2006) notes that the literature on the compatibility and combination of Six Sigma and Lean is limited and, moreover, disappointing when examined for a common model, theoretical compatibility or mutual content or method.

Mader (2008) suggests there are three models that have been presented in the literature, namely the Traditional model involving Six Sigma only (TSS); the traditional model using Lean only (TL); and a combination of Lean and Six Sigma as either a Lean Six Sigma Light (LSSL) or Lean Six Sigma plus (LSS+).

The TSS model was developed by Smith (1991) and then expanded into the Define-Measure-Analyze-Improve-Control (DMAIC) methodology by Harry and

Schroeder (2000). The TSS model was deployed in Allied Signal and General Electric and other large organizations in the US. Mader (2008) suggests that TSS effectively integrates each of the Body of Knowledge for Six Sigma, Business Process Reengineering and project management. Evans and Lindsay, (2005) suggest that the TSS model embraces quality management with a focus on advanced statistical method as the cornerstone of its definition.

The deployment of the TSS model in the manufacturing sector has sometimes been combined with the International Quality Management Standard ISO9001 as evidence of the use of a continuous improvement methodology (Pfeifer, Reissiger and Canales, 2004). Under the TSS model the Black Belt is allocated to the projects full-time and the projects are scoped to last about four months (Mader, 2008).

The TSS model has been applied in many different industry sectors, including health, banking, finance and service as well as manufacturing. Antony *et al* (2007a) illustrate the point that the TSS model is not confined just to manufacturing industry, rather it is equally applicable to service industry, especially the healthcare and financial sectors.

During the mid-1980's, the Toyota Production System (TPS) was gaining popularity among traditional manufacturing companies as they responded to Japanese competition. The TPS was an improvement philosophy embraced by all employees (Becker, 2001). This is the TL model described by Mader (2008). Under this model, tools from the Toyota Production System are applied systematically to repetitive processes involving flow of material, transactions or physical product and there may not be any Six Sigma "Belts" leading the projects but rather the Lean practitioners would be the project leaders (Mader, 2008). Essentially, the TL model is about the elimination of waste (Shah and Ward, 2007).

Lean implementation started in manufacturing without any reference to Six Sigma and still exists in many companies (mostly smaller and medium-sized ones) mainly because Six Sigma is seen to be costly to implement because of the training costs (Davis, 2003) and is difficult to implement because of the emphasis on statistics and it requires significant resources (Antony, 2008a).

Shah et al. (2008) establishes empirically that firms with extensive implementation of Lean practice are also likely to implement most of the practices of Six Sigma. Also, Lean practices can be taught quickly and yield rapid improvements and so there is a tendency to focus on Lean first (Jorgensen, 2004).

There are two versions of the Lean Six Sigma model referred to as the Lean Six Sigma Light (LSSL) and the Lean Six Sigma Plus (LSS+) and the actual tools and techniques used within each of the phases of the latter two models can vary (Mader, 2008).

The LSS+ model of Mader (2008) is used when the objective is about flow of work rather than quality of work and there is less emphasis on quantitative analysis. This model provides flexibility in problem solving and economy of scale in deployment costs. Under the LSS+ model, champions and Master Black Belts determine the type of problem under consideration and then determine the method best suited to the problem in terms of time, cost and quality. If a Six Sigma approach is warranted, a project is launched under the TSS model. After the analyze phase is completed, the Champion and Black Belt could decide that Lean tools might provide a more effective solution.

For the LSSL model, the DMAIC structure is followed and use is made of a limited set of Six Sigma tools (tending towards the simpler ones) and the mainstream Lean tools like 5S, Value Stream Mapping, Total Preventive Maintenance, Visual Workplace, Error Proofing and Quick Changeover. This is consistent with the work of Kumar *et al* (2006) in which a proposed framework in an small company in India involves integrating Lean tools (current state map, 5S system and Total Preventive Maintenance) within the DMAIC methodology to enhance the bottom-line results and win customer loyalty. Implementation of the proposed framework shows dramatic improvement in the key metrics (defect per unit, process capability index, mean and standard deviation of casting density, yield, and overall equipment effectiveness) and a substantial financial savings is generated by the organization.

This is also consistent with the work of Laureani, Brady and Antony (2013) in which the primary methodology is a case study of the implementation of Lean Six Sigma techniques through a series of student projects carried out in a hospital setting. Lean in the case of three projects, Six Sigma in the case of one project and mistake proofing in the case of the final project. The most commonly used supporting techniques were process mapping, seven wastes, 5S and logic tree/root cause which were each used in two of the five projects. Other techniques used were control charts, checklists and theory of constraints, which were each used by one project team. Support from top management and regular communication with stakeholders were identified as key factors for success by three of the five project teams.

The LSSL model may not be well suited as a method for solving all problems in operations, but it has a definite benefit when applied to smaller scope projects under a Kaizen philosophy. Generally, the length of the DMAIC project cycle is less than for the TSS model. The main drawback to this approach is that when a problem is encountered that cannot be readily addressed using Lean or basic Statistical tools, the solution tends to be sub-optimal that might necessitate further improvement efforts in the future (Mader, 2008).

Vavra (2007) suggests that starting with a Lean strategy and augmenting it with Six Sigma allows for the plant to measure the process and people involved in manufacturing. This appears to be taken up by most non-manufacturing organizations. Greene (2007) uses a redesign deployment model involving Lean along with the Six Sigma design change principles using "DMADV".

Gershon and Rajashekharaiah (2011) suggest there is no established model for Lean Six Sigma but there has been a clear evolution to Lean Six Sigma and it appears that the DMAIC methodology is used as standard practice. It is not clear what tools and techniques are appropriate in each phase.

A systematic approach needs to be adopted, which optimizes systems as a whole, focusing the right strategies in the correct places (Pepper and Spedding, 2010).

A new model called L6QMS 2008 has been developed from the process-based Quality Management System model of the International Standard ISO 9001. This model integrates the Lean Six Sigma requirements as appended additional sub-clauses in the ISO 9001:2008 standard (Karthi, Devadasan and Murugesh, 2011).

### 2.8.4 Deployment in Small and Medium Sized Enterprises (SMEs)

Small and medium-sized enterprises (SMEs) tend to focus on simpler continuous improvement models sometimes within the International Standard for Quality (ISO9001) or TS16949 (the equivalent in the automotive supply chain) using regular Kaizen events (Bhuiyan and Baghel, 2005; Chin-Hung, 2009; Pfeifer *et al.*, 2004; Warnack, 2003) or simpler versions of the combination of Lean and Six Sigma (Davies, 2005; Davis, 2003; Harry, 2004; Mader, 2008; Wessel and Burcher, 2004).

A Six Sigma deployment framework has been developed for SME's by Wessell and Burcher (2004). This study was based on a sample of 20 SME's in Germany and examines how Six Sigma has to be modified to be applicable and valuable in an SME environment. Because an SME usually does not have the capital base and infrastructure to implement Six Sigma as adopted by larger companies, these authors have developed a list of conditions for Six Sigma to be deployed successfully in an SME. The key differences include:

- Every single project has to contribute positively to the bottom-line
- Projects need to be closely tracked
- A training program needs to ensure cultural uptake
- Only one Black Belt is necessary
- An understanding of process management strategies is important
- Use of consulting services that are modular in form
- Adjust Six Sigma to ISO9001/2000 to allow automatic certification.

For SME's there is a need of practical implementation framework for successful deployment of Six Sigma (Kumar *et al.*, 2011). Antony *et al* (2005) found that Six Sigma was generally not popular among SME's. Their final analysis studied 60 SMEs that responded out of 400 and found that - 35% of respondents using Lean Six Sigma had no project champion; one company has a MBB; 80% use only Green Belts; 19% were using design for Six Sigma; 6% were using Lean Six Sigma and 6% were using Six Sigma and Design for Six Sigma.

Davis (2003) suggests that expensive investment is required for the implementation of Six Sigma and the traditional top-down Black Belt implementation approach is suggested to be a barrier for SME's. As a strategy in SME's, Davies (2005) suggests that Six Sigma champions should be used to provide a strategic view of the implementation and consider a more flexible approach to the training and deployment in which most Black Belts are employed on a part-time basis on projects. Nevertheless, small companies can easily implement change programs like Lean and/or Six Sigma because of their relative informality and ease of communication (Welch and Welch, 2007).

Prasanna and Sekar (2013) study the deficient characteristics of SME's suggesting that the deployment of Lean, Six Sigma or Lean Six Sigma in an SME is not easy. Amongst these deficiencies are – poor management skills; inadequate training; poor infrastructure and poor leadership.

Quality management culture has largely been ignored or given less importance in the SME sector, which is evident from the meagre literature. There is a dearth of clear and SME-specific methodologies relating to Six Sigma and there are far fewer models for quality improvement in the SME sector (Deshmukh and Chavan, 2012).

### 2.8.5 Deployment in Service (non-manufacturing) Enterprises

Lean Six Sigma began in the industrial sector and has since spread to many other areas in the non-manufacturing sectors including health care, education, government services, hospitality and financial services. The applicability of Lean Six Sigma to the service sector has been a controversial topic generally

(Alessandro, Antony and Alex, 2010) and particularly controversial in human resources (Alessandro and Antony, 2010). One of the key reasons for this controversy is the fact that there is limited data on processes in a service setting and the opportunity to use advanced statistics within the DMAIC phases is low (Patton, 2005).

The deployment models in service seem to be a mixture of Lean, Quality and statistical tools but not the TSS model of Mader (2008). For example, in a study using the National Health Service in Scotland, Antony (2008b) found that the most popular tools and techniques used included Benchmarking, Brainstorming, Patient Feedback, Process Mapping and Root Cause Analysis. Slightly more complex tools like mistake proofing, Failure Mode and Effect Analysis (FMEA), Total Productive Maintenance (TPM), Supplier-Input-Process-Output-Customer, Quality Costing, 5S Practice, Value Stream Mapping, Single Minute Exchange of Die and Non-Parametric tests were not popular in many hospitals across Scotland.

Lean Six Sigma has been widely deployed in the health sector where the defects are less tolerable followed by the military; government organizations; financial services mainly banks and in the information technology and related industries like telecommunication and computer manufacturing (Zhu and Hassan, 2012). However, these new practices have been developed in Healthcare substantially without a theoretical foundation (Linderman *et al.*, 2003). The use of Six Sigma in US hospitals generally began in 2002, followed by Lean four years later (Buell, 2010). Most problems that hospitals address using Lean Six Sigma are strategic and non-clinical in nature such as streamlining throughput and the supply chain. But a trend has emerged in which organizations specifically use it to tackle patient safety issues, for example patient falls, medication errors and pressure ulcers, medication management, patient handoff communication and labeling supplies in operating rooms and a reduction in hospital-acquired infections (Buell, 2010).

In a study of an emergency department in a hospital, it was found that simpler tools of quality and statistics including a Failure Modes & Effects Analysis, process maps and a cause and effect diagrams were used to make improvements to patient waiting time using a project team made up of physicians and nursing staff (Johnson, Shanmugam, Roberts, Zinkgraf, Young, Cameron and Flores, 2004). Using the US healthcare system as an example, Hoerl and Gardner (2010) comment that organizations seeking long-term success need a balanced approach to business improvement that includes basic problem-solving, deployment of continuous process improvement and also systems to identify opportunities for disruptive innovation.

Lean appears to be used separately and fairly widely across the service sector because of its focus of improving the speed of operations but in many cases, improvement projects need to leverage a combination of Lean and Six Sigma approaches and tools to be successful (Ray and Boby, 2011).

Lean Six Sigma projects at the enterprise-level in banking have included streamlining records management processes and improving the ways information flows into, through and out of banks with diverse teams formed to work on structures and solutions (Brett and Queen, 2005). Interestingly, both Lean Six Sigma and TQM techniques (for example Statistical process Control) are used jointly in improving the competitiveness of banking and service industries in the U.S (Bin Jumah, Burt and Buttram, 2012). This article indicates that TQM still is used and there is an overlap between Lean Six Sigma and TQM in terms of tools and techniques.

For the banking sector, pressures to reduce costs, the desire to exploit market opportunities and dissatisfied customers are the main drivers (Heckl, Jürgen and Rosemann, 2010). For banking, the uptake of Six Sigma is still in the early stages and most companies apply the methodology in pilot projects only (Heckl *et al.*, 2010).

### 2.8.6 Lean Six Sigma Deployment Strategies and Models

Figure 2.2 demonstrates the deployment strategies and models being discussed in the literature. In this figure, SME's both in manufacturing and service would traditionally be focused on Traditional Lean or LSS Light and larger multinationals in manufacturing and service with significant resources would include Six Sigma in their deployment strategy at some stage.

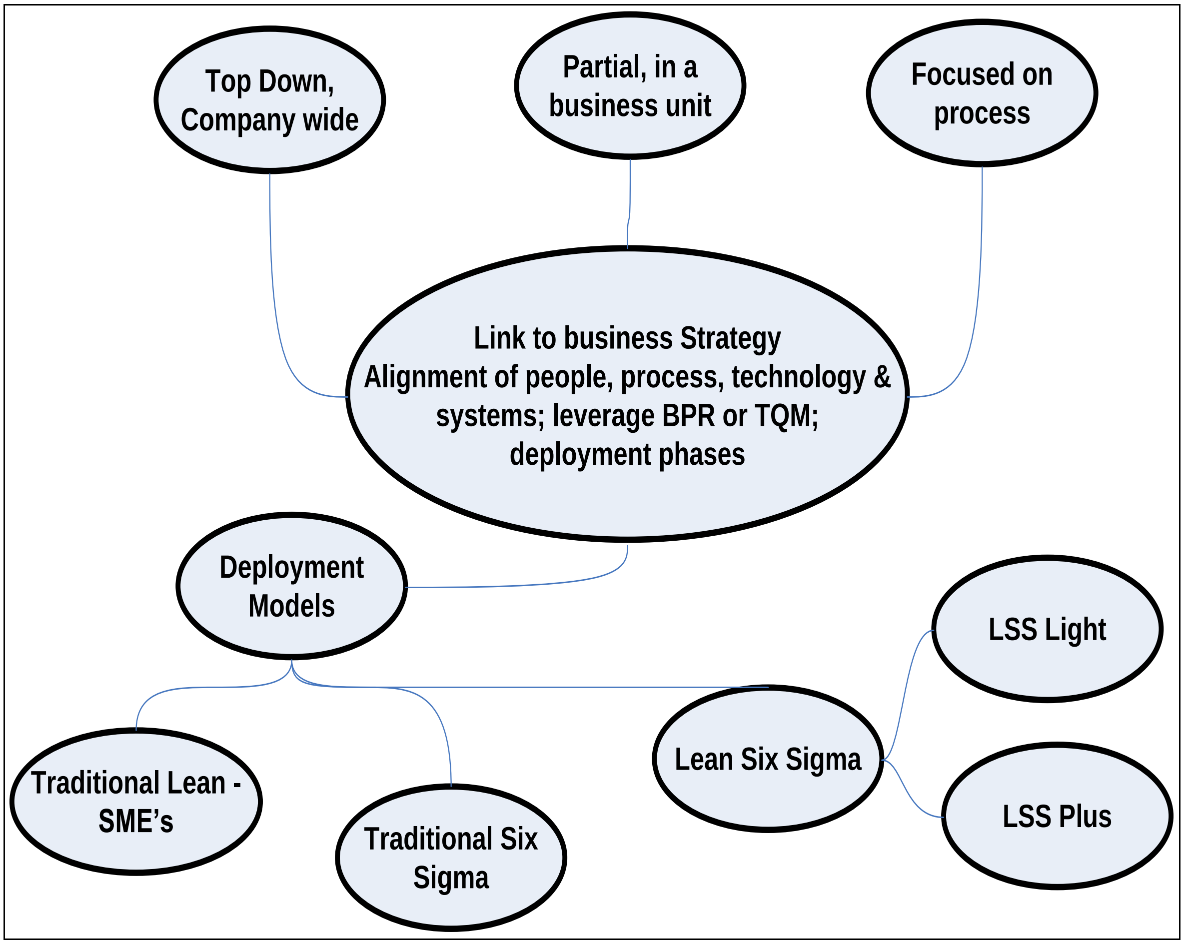


Figure 2.2: Model of Deployment Strategies in Lean Six Sigma

### 2.8.7 Development of Research Question 2

Linking Lean Six Sigma to the strategy of the business by aligning projects, people and processes is the intent of Lean Six Sigma deployments. Deployment can be top-down/company-wide, partial in a business unit or process focused. Pilot projects can reduce the risk during deployment. Divisional level rather than enterprise-wide deployments are more common in service because of the size of these organizations.

The likelihood of deployments for SME's training a number of Black Belts is low because the cost of this training is prohibitive. Improvement projects for SME's need to be focused on successful outcomes due to a lack of resources being allocated full-time.

In the literature review, the deployment of Lean Six Sigma in service has been slower and Lean is the predominant model since good data is lacking  In these organizations (Julien and Holmshaw, 2012). It has been deployed without a theoretical foundation but has been modeled on manufacturing. The order of deployment of Six Sigma and Lean in service varies  (Patton, 2005).

TQM is still used in many sectors and has been combined, in some sectors (e.g. Banking), with Lean Six Sigma. Lean Six Sigma has been leveraged off TQM acknowledging that the latter was successful in some areas.

The tools within the phases of DMAIC for Lean Six Sigma have not been clearly stated but appear to have been based on Six Sigma phase tools with Lean added where appropriate. In particular, it is clear that the phases of a Six Sigma methodology are well-defined but there has been little attention given to the definition of what constitutes a Lean Six Sigma methodology. For example, in many companies Lean Six Sigma deployments use the DMAIC methodology and also use Lean tools at various stages and in others Lean is separately deployed concurrently with DMAIC.

Further, the use of tools will vary within the DMAIC phases based on the project focus and amount of data available.

Some companies have deployed Six Sigma first then Lean and other companies have deployed Lean first to identify low-hanging fruit and then implemented Six Sigma and others have implemented the combined program from day one. Another point is that the literature suggests that deployment of Lean Six Sigma needs to be different in SMEs.

Based on the above discussion and the literature review in sections 2.7.2 to 2.7.6, where a number of issues and contradictions are raised relating to Lean Six Sigma deployment strategies and models, the second research question has been developed, namely what are the characteristics of the way Lean Six Sigma has been deployed and is it affected by organizational size?

In fieldwork phase 1 (Chapter 4), fieldwork phase 2 (Chapter 5) and fieldwork phase 4 (Chapter 7), deployment strategies and models for Lean Six Sigma are investigated further in order to provide insights and/or challenge current theory and practice.

## 2.9 Competencies – Organizational and Personal

### 2.9.1 Introduction

Factors critical to success of Lean Six Sigma have been identified in the literature. It is unclear whether these factors are critical to short-term gains or long-term sustainable benefits. Included in these critical success factors for Lean Six Sigma is the need for highly-trained Lean Six Sigma experts (Master Black Belts, Black Belts and other levels of Belts) and the importance of corporate or organizational factors.

In the literature, the concept of a competency-based perspective of these factors is introduced.

Both Eriksen (1996) and Sanchez (1996) suggest that a company needs to have the assets, skills and resources necessary to perform some selected activities systematically in order to achieve a better competitive position in the market place. According to these authors, the competencies have a cognitive aspect in terms of knowledge and skills the company possesses and an action aspect that enables a company to deploy its competencies in a coordinated manner. Organizations achieve sustained success through the integrated functioning of people, processes, and technology. The strength of organization development lies in its roots in organizational behavior and dynamics, and the application of action research to improve human performance and organizational effectiveness.

In order to adopt Six Sigma as a rigid data-driven approach to achieve higher quality performance in the long-term, it has been suggested that a company must develop a unique combination of resources and competencies that "bring home" the benefits (Huq, 2006). This competency-based perspective means that a company firstly, needs to have the assets, skills and resources to launch a quality initiative such as Six Sigma and secondly, it needs to have the expertise to integrate these assets to orchestrate a cohesive implementation of the initiative.

According to Huq (2006), the capability of an organization includes both personal and corporate competencies. Personal competencies comprise the technical knowledge and charisma of the Six Sigma facilitators leading the Lean Six Sigma deployment (Master Black Belts) and project leaders (Black Belts). Corporate or organizational competencies comprise a combination of skills, knowledge and experience that enable a firm to implement a change program successfully (Dunphy, Turner and Crawford, 1997). These skills and knowledge are embedded in a corporate culture and work methods and these can only develop through continual process improvement efforts (Huq, 2006).

In this sense, organizational competencies are representative of the factors that are critical to a successful deployment of Lean Six Sigma. In the case of Lean, the Toyota Motor car company through its Production System (Toyota Production System) has developed a set of key principles which include a competency based strategy to implement Lean (Liker and Meier, 2006). A number of these principles involve developing a long-term philosophy, selecting the right process to produce the right results, adding value to the organization by developing people and partners and continually solving the root causes of problems, all of which drive organizational learning.

In the next section, literature is reviewed on organizational competencies followed by a review of the literature on personal competencies of the Master Black Belts and Black Belts.

### 2.9.2 Organizational Competencies

Organizational competencies may refer to the ability of an organization to "Absorb previous initiatives", that is the ability to deploy an improvement program if similar concepts have been deployed (Shah *et al.*, 2008). According to Warnack (2003), linking Six Sigma to the disciplines of an effectively administered ISO 9001 quality management system can help organizations ensure success of the deployment by creating a single point of reference for all continual improvement activities; clearly defining the critical features of the business improvement program; and using an established internal audit methodology that can be tailored to the specific needs of the business improvement program to ensure ongoing effectiveness of that particular program. Links between ISO quality management systems and Six Sigma have been further supported by Marques, Requeijo, Saraiva and Frazao-Guerreiro (2013) and Kumar, Antony, Madu, Montgomery and Park (2008).

Van Iwaarden *et al*. (2008), using a detailed survey, conclude that a certain level of quality management is a prerequisite for successful deployment of Six Sigma and also a well-guided and clear cut strategy is required by an organization to seek the long-term benefits.

Manville *et al* (2012) shows that organizations must support dynamic capabilities in middle management along with a learning culture will facilitate participation in strategy formulation. Using case studies, Timans *et al* (2012) confirms that the organization must support the personal Lean Six Sigma experience of top management, the development of the project leader's soft skills and a supply chain focus as well as a communications culture that is widespread that can be sustained in the long-term (Pande *et al.*, 2000).

Performance can be defined as the achievement of purpose and desired results (Anderson, 2011). An organization in which communication in pursuit of purpose are not accepted as authoritative and willingly assented to by subordinates is an organization that will not achieve its purpose (Anderson, 2011). Too often, in many firms, continuous improvement programs and initiatives have been issued as directives from top management, and because these directives are not accepted as authoritative by subordinates, their assent is only partial at best, and the initiatives flounder and fail. Lean Six Sigma will not be successful unless certain attributes are attained, for example, high levels of organizational commitment, employee autonomy, information transparency (Scherrer-Rathje, Boyle and Deflorin, 2009) and changing the management paradigm (Babbit, 2010).

According to Anderson (2011) for continuous improvement programs to succeed, top management needs to ensure that the essential conditions for the proper wielding of authority are present. Proponents of Lean and Six Sigma have, in Anderson's opinion, given scant regard to how human relationships function within an organization, and how the cooperation and contribution necessary from members for successful implementation will be induced and elicited. In the worst cases, the lack of assent to "authoritative" communication and directives by subordinates manifests itself not just as passivity, but as outright resistance. How often, for example, have we seen an organization try to implement *kaizen*-type initiatives driven by directives from top management and the buy-in from lower levels is totally passive or even hostile (Anderson, 2011).

It has been suggested that technological capability is the key to short-term success and long-term survival (Sangmoon and Youngjoon, 2006). During the transformation, Samsung's corporate R&D centre enhanced its R&D capabilities by aligning with business strategies and integrating R&D processes with Design for Six Sigma. The success of the transformation included consensus on the need for organizational change, strong leadership from top management, close alignment of R&D and the business units, and actionable planning and performance management (Sangmoon and Youngjoon, 2006).

In an interview, Jack Welch (Welch and Welch, 2007), previously chairman of GE noted the following as competencies within an organization that were necessary for the success of Six Sigma:

- Radical change is difficult and needs to be overcome
- Widespread communication is critical from the senior executives to all the managers throughout the company
- Put the fear in everyone
- Talented young people

- A culture of fun and challenge.

Welch noted that the third point was extreme but it was necessary to change the mindset of the business. This was in contrary to one of Deming's 14 points in which it was important to "Drive out fear" (Deming, 1986).

Davidson and Al-Shaghana (2007) investigates empirically influences on quality culture development. Questionnaires were designed to measure organizational factors, including the use of proposed cultural change agents, and relative quality culture development. Fifteen organizations of varying types were then surveyed. The Six Sigma group was found to have higher mean scores for all quality culture dimensions, and also had slightly stronger homogeneous cultures. Organizational factors having significant relationships with the development of a quality culture were found to be: demonstration of management commitment to quality, creating awareness of quality, training, employee participation, and performance evaluations based on quality-related criteria. Six Sigma organizations, on average, scored higher on these factors than did non-Six Sigma organizations concluding that the organizational factors may play a part in the development of a quality culture.

A point to be made is that some researchers have shown that the factors critical to a successful deployment of Six Sigma have been shown to be uniquely different for SME's (Antony, 2008a; Antony *et al.*, 2005; Wessel and Burcher, 2004). However, it is possible that there are some underlying organizational competencies that apply no matter the size and type of the organization. For example, if organizations do not obtain high levels of organizational commitment, employee autonomy and information transparency (Scherrer-Rathje *et al.*, 2009) and are not able to change the management paradigm (Babbit, 2010) then they will not be successful. Leadership, management, finance organizational culture and skills and expertise are critical competencies of Lean Six Sigma, according to (Achanga, Shehab, Rajkumar and Nelder, 2006).

Timans *et al* (2012) extends these critical factors to include project leader's soft skills, linking to customers, vision and plan statement, communication and management involvement and participation and internal resistance, the availability of resources, changing business focus and lack of leadership are the strongest impeding factors. The use of the right tools, measurement assurance, innovation strategies and supplier collaboration are suggested to be the top factors by Sharma (2012).

Other notable research using empirical evidence to determine the critical success factors for Six Sigma have been provided by:

- Antony (2004a), Antony *et al.* (2007a), Van Den Heuval, Does and Bisgaard (2005) and Chakraborty and Tan (2013) for service organizations.
- Kumar and Anthony (2009), Antony (2005), Wessel and Burcher (2004), Dora, Van Goubergen, Molnar, Gellynck and Kumar (2012) and Timans et al (2012) for SMEs.
- Lee *et al*. (2006), Knowles et al. (2004), Antony and Banuelas (2002), Nurul Fadly and Sha'ra Mohd (2013) and Zu *et al*. (2010) for manufacturers.

From the above review, a number of broad factors that impact on the successful deployment of Lean Six Sigma are identified and have been categorized into five broad groups as presented in Table 2.4.

| **CSF** | **Category** |
|---|---|
| 1 | Factors relating to leadership, structure, behavior and awareness of Lean Six Sigma |
| 2 | Factors relating to policies, culture, organizational support, communication and strategy |
| 3 | Factors relating to education, training and competency of the Lean Six Sigma experts |
| 4 | Factors relating to project improvement teams and project management |
| 5 | Factors relating to performance evaluations based on quality criteria, information systems, data and measurement |

Table 2.4: Broad factors for success in deploying Lean Six Sigma

Factors 1 to 4 in Table 2.4 are consistent with the finding of Dora *et al* (2012).

All five broad groups are consistent for the factors identified by Lee and Choi (2006) for Six Sigma as noted below:

- factors relating to policies, culture and organizational support and strategy for sustainable promotion of Six Sigma, for example:
    - Compensation for participating in Six Sigma
    - Six Sigma training results appearing in personnel management
    - Six Sigma qualifications required for promotion.
- factors relating to information systems and measurement, for example:
    - Systematic data management
    - Importance of team members understanding data
    - Periodic updates of data
- factors relating to communication, behavior and awareness of Six Sigma throughout the organization, for example:
    - Team members sharing the corporate strategy
    - Fluent communication between all levels of the organization
    - Sharing information relating to Six Sigma.
- factors relating to education, training and competency of the Six Sigma practitioners, for example:
    - Task related training
    - Training on various analytical tools
    - Sustaining implementation of education.

All five broad factors are also consistent with the work of Banuelas and Anthony (2002) which are described as follows:

- Top management support; Organizational structure; Business Plans
- Change management and organizational culture
- Effective communication, education and training, knowledge transfer, knowledge management (including skills and expertise)
- Project Management (including project champion, teamwork and composition)
- Monitoring and evaluation of performance, performance measurements.

The factors in Table 2.4 are also consistent with the possible grouping of constructs identified by Powell (1995) for TQM, noted in Table 2.5.

| Factor | Description/Construct |
|---|---|
| 1 | Executive Commitment |
| 2 | Adopting the philosophy - Culture, Zero defects mentality |
| 3 | Linkages with customers and suppliers |
| 4 | Improvement Methodology tools and techniques |
| 5 | Training, experience and competency of facilitators |
| 6 | Benchmarking and other measurements |
| 7 | Open organization |
| 8 | Employee empowerment |
| 9 | Linkages with lean operations |
| 10 | Linkages with quality systems |
| 11 | Project Management |

Table 2.5: Factors critical to a successful TQM deployment – Source (Powell, 1995)

From the specific comments made in section 2.8.2 and a review of the general literature using critical factors for success as a search category, examples of some of the competencies (constructs) within each broad category are shown in Table 2.6.

An additional category for Lean Six Sigma relating to management of project teams has been added as this links with the research findings from TQM (Powell, 1995).

It is clear that more recent journal articles have found similar constructs as critical factors when applying to their research data. Nevertheless, every construct seems to fit into one (possibly two) of the broad factor categories. For example, Keeley, van Waveren and Chan (2012) suggests that there are 12 critical success factors

1. A clearly defined Six Sigma deployment plan

2. Active participation and the commitment of the senior executives in the Six Sigma deployment
3. Regular Six Sigma project reviews
4. Technical support from Six Sigma Master Black Belts and Black Belts
5. Full time Six Sigma Master Black Belts and Black Belts
6. Six Sigma training programmes for all employees
7. A plan to communicate the Six Sigma programme to the entire organisation
8. A Six Sigma project selection methodology
9. A system to track all Six Sigma projects
10. A Six Sigma incentive programme
11. A safe environment that allows employees to tell the truth regarding their respective areas of responsibility
12. A clear plan for dealing with internal and external suppliers.

To explain this further, points 1, 2 can be possible constructs for broad factor 1. Points 11 and 12 can be possible constructs for broad factor 2. Points 4 and 5 can be possible constructs for broad factor 3. Points 3 and 8 can be possible constructs for broad factor 4 and finally, point 9 can be a possible construct for broad factor 5. Clearly, some constructs may overlap depending on their interpretation.

### 2.9.3 Development of Research Question 3

The broad factors critical to a successful deployment of Lean Six Sigma can be divided into five broad categories of factors including leadership, culture, training, project management and data measurement (Table 2.4). These categories apply to manufacturing and service and SME's but the constructs within each category may vary. These broad categories represent a set of factors that drive improvement success and are what organizations must focus on no matter what particular improvement model has been deployed (Lean, Six Sigma, Lean Six Sigma or TQM).

Based on the above discussion and the literature review in sections 2.9.1 and 2.9.2, where a number of issues are raised with respect to the relationship between organizational competencies and critical factors for success of Lean Six Sigma, the third research question has been developed, namely what are the competencies of an organization that result in the successful deployment of Lean Six Sigma?

The organizational competencies are further developed in fieldwork phase 1 (Chapter 4) and phase 2 (Chapter 5) to gain further insights into the competencies or constructs comprising the broad factors developed.

| Factor Category | Example of constructs and reference |
|---|---|
| **Factors relating to leadership, structure, behavior and awareness of Lean Six Sigma** | • Top management commitment (Banuelas *et al.*, 2006; Antony, 2007; London, 2002; Malik and Blumenfeld, 2012; Ray and Das, 2010)<br>• The need for active support and engagement of all business process owners in Six Sigma project implementation down the line must be enlisted (Byrne, 2003)<br>• Ease of Six Sigma champions in negotiating resources (Lee, 2002)<br>• Management team buy-in, participation and involvement in projects (Waxer, 2004)<br>• Cascading of the Six Sigma knowledge and work practices down the organization (Byrne, 2003)<br>• Engaging workers at the plant floor level (Vavra, 2007)<br>• More responsibility given to middle management in performance improvement and strategy formulation (Manville *et al.*, 2012)<br>• Well defined interfaces and roles with the existing organization (Van Den Heuval *et al.*, 2005)<br>• Mentoring and guidance by the Black Belts (Knowles *et al.*, 2004)<br>• senior management support and enthusiasm (Manville *et al.*, 2012)<br>• management engagement (Jeyaraman and Teo, 2010); (Jayaraman, Teo Leam and Keng Lin, 2012)<br>• frequent communication and assessment of results (Jeyaraman and Teo, 2010) |
| **Factors relating to policies, culture, organizational support, communication and strategy** | • Substantial change in the organization structure and infrastructure (Banuelas and Antony, 2002)<br>• A culture without fear of change otherwise people resist because of the fear of the unknown (Antony and Banuelas, 2002)<br>• Creative thinking and a communications culture, to support dynamic leadership, that is widespread so that the Six Sigma program can be sustained in the long-term (Pande *et al.*, 2000)<br>• A communication plan to reduce resistance to change (Henderson and Evans, 2000)<br>• Six sigma knowledge and work practices cascading down the organization to ensure the right culture of continuous improvement (Byrne, 2003)<br>• A group culture (participation, teamwork, facilitator-type leader, people and commitment), development culture (creativity, flexibility, entrepreneurship-type leader, innovation and new resources) and rational culture (efficiency, task focus, achievement-type leader, goal orientation and competition) (Zu *et al.*, 2010)<br>• how employees deal with change (Joyce, 2004)<br>• A shared understanding of core business processes and the critical characteristics, rewarding and recognizing the team members and communicating the success and failure stories (Spanyi and Wurtzel, 2003)<br>• An environment for innovation and creativity and systems thinking (2003a)<br>• To embed an improvement into the culture of a business is to integrate the improvement process as a procedure into the Quality Management Systems (Pfeifer *et al.*, 2004)<br>• Without organizational learning there can be no continuous improvement (Wiklund and Wiklund, 2002)<br>• Linking LSS to business strategy and the customer (Manville *et al.*, 2012)<br>• Reward and recognition system (Jeyaraman and Teo, 2010)<br>• Sharing project success, best practice and benchmarking (Jeyaraman and Teo, 2010)<br>• Organizational belief and culture (Jeyaraman and Teo, 2010) |
| **Factors relating to education, training and competency of the Lean Six Sigma experts** | • Leadership, management, finance organizational culture and skills and expertise (Achanga *et al.*, 2006)<br>• development of the project leader's soft skills (Timans *et al.*, 2012)<br>• Training and education (Manville *et al.*, 2012), (Jeyaraman and Teo, 2010)<br>• The knowledge, skills and experience of the Six Sigma experts (Snee, Hahn, Hoerl and Hill, 2003), (Snee *et al.*, 2003), (2004) and (Antony, Douglas and Antony, 2007b)<br>• Black Belts must be selected on the basis of competencies necessary for the job and also must address the needs of the individuals as well as the requirements of the job (Byrne, 2003)<br>• The importance of training "Belts" in many different facets including statistical software, project management, team dynamics, statistical tools, problem solving and leadership as critical to the success of Six |

| | |
|---|---|
| | Sigma (Lee, 2002)<br>• A need to understand process management strategies for SMEs (Kumar *et al.*, 2011), (Wessel and Burcher, 2004)<br>• Organizational competency is the ability of an organization to "Absorb previous initiatives", that is the ability to deploy an improvement program if similar concepts have been deployed before – for example, Lean deployment firstly followed by Six Sigma training and deployment (Shah *et al.*, 2008)<br>• Communication training (Gorman, 2004)<br>• Understanding the tools and techniques (Manville *et al.*, 2012)<br>• Competency of Master Black belt and Black belt (Jeyaraman and Teo, 2010)<br>• Hierarchy of responsibilities (Magnusson, Kroslid and Bergman)<br>• Support of the project leader's soft skills and a supply chain focus (Timans *et al.*, 2012) |
| **Factors relating to project improvement teams** | • project selection and prioritization (Manville *et al.*, 2012), (Jeyaraman and Teo, 2010)<br>• Selecting the right people and the right projects is critical to success (Hu, Wang, Fetch and Bidanda, 2008), (Spanyi and Wurtzel, 2003), (2005), (1999) and (Lee, 2002)<br>• Mentoring/guidance of the cross-functional teams by experienced practitioners, training linked closely to application and linking team results to organizational objectives and measures help to embed Six Sigma (Knowles *et al.*, 2004)<br>• A need for every single project to contribute positively to the bottom-line and projects need to be closely tracked (Wessel and Burcher, 2004)<br>• Training or team training is not successful unless reinforced by regular follow up of an ongoing systematic change in how work is conducted (Wiklund and Wiklund, 2002)<br>• Review and tracking (Jeyaraman and Teo, 2010) |
| **Factors relating to performance evaluations based on quality criteria, quality information systems, data and measurement** | • Constancy of purpose, financial rigor by experienced analysts, data capture and knowledge management (Motwani *et al.*, 2004)<br>• The tools and techniques within the Six Sigma methodology have a role to play and when, where, why and how these tools or techniques should be applied is the difference between success and failure of a Six Sigma project and there must be a clear focus on achieving measurable and quantifiable financial returns to the bottom line of an organization and there must be an emphasis on statistical analysis of process data, measurement systems analysis and decision making based on facts and data rather than assumptions and hunches (Antony, 2004b)<br>• Performance evaluations based on quality-related criteria (Davison and Al-Shaghana, 2007)<br>• The use of consulting services that are modular in form and adjusting Six Sigma to ISO9001/2000 to allow automatic certification (Wessel and Burcher, 2004)<br>• Combine with International Standards and Quality Management Systems (van Iwaarden *et al.*, 2008), (Munro, 2000), (Karthi *et al.*, 2011) and (Warnack, 2003)<br>• Disciplined and effective problem solving and decision behavior has the potential as a source of competitive advantage, rather than just conducting Six Sigma projects by the book (De Mast, 2006)<br>• There must be a framework for continuous process improvement with a system of indicators for monitoring progress and success and business processes linked to measurable financial results (Pyzdek, 2003a)<br>• Company financial capability (Jeyaraman and Teo, 2010)<br>• Established LSS dashboard (Jeyaraman and Teo, 2010)<br>• right tools, measurement assurance, innovation and supplier collaboration are suggested to be top factors by Sharma (2012) |

Table 2.6: Examples of Organizational competencies for Lean Six Sigma

### 2.9.4 Personal Competencies

#### 2.9.4.1 Introduction

An organization's competitive advantage will come from the quality and competence of its human capital and the ability of its managers and leaders to leverage this talent successfully (Fleming and Asplund, 2007). In particular, the training and education of the Lean Six Sigma program facilitator, usually referred to as a Master Black Belt and the Black Belts that lead the projects are critical to success (Antony, 2007; Antony and Banuelas, 2002; Black and McGlashan, 2006; Byrne, 2003; Defeo, 2000; Hoerl, 2001; Pyzdek, 2009; Wiklund and Wiklund, 2002).

It is clear that, in the field of Lean Six Sigma where standards are critical there is a lack of a standard for certification to demonstrate competence. This generates confusion, a parallel industry for certification practices and lack of trust and confidence on the professionals in the field (Alessandro and Antony, 2012).

This next section examines the specific competencies that are appropriate to be an effective project leader or Black Belt, followed by a section that examines the additional competencies of the deployment facilitator or Master Black Belt and then followed by a section that discusses the influence level of the Master Black Belt.

#### 2.9.4.2 Black Belt Competencies

When Black Belts become certified, it does not signify the end of their studies. They must make a commitment to continuous learning (Snee *et al.*, 2003). Pre-requisite education for Lean Six Sigma experts and training programs in Lean Six Sigma vary considerably. Academia must play a role in developing pre-requisites for experts in the field of Lean Six Sigma (Antony, 2008c).

Defeo (2000) concludes that the Black Belt must demonstrate management and leadership skills; have a background in mathematics, statistics and analysis; a basic understanding of the business process and of finance and be a potential future manager or desire other advanced professional positions. Hoerl (2001) suggests that a Black Belt must have statistical skills; organizational effectiveness skills e.g. team and project management; meeting management skills, training skills and be able to present the results of projects.

Using a case study organization in Sweden, Wiklund and Wiklund (2002) suggest that Black Belts in Lean Six Sigma should demonstrate competencies in leadership, change management, learning aspects and self-knowledge, supervision strategies, statistics and finance and behavioral science. Black Belts must have an in-depth knowledge of behavioral science as this is one facet for the basis of increased organizational learning and that there must be support for the Black Belts when they start to implement projects. For example, a finance expert should advise them in the project business case, a statistician should advise them on application of advanced statistics and a behavioral scientist should support their roles as consultants (Wiklund and Wiklund, 2002).

Byrne (2003) suggests that a Black Belt must have a clear understanding of their company's business strategies and objectives; a strong process orientation; a solid knowledge of, and the ability to apply, statistical/analytical tools and techniques; strong facilitation, teaching and team building skills; change management skills and experience and cross-functional business and work experience. Mitra (2004) makes the point that Black Belts need a sound statistical education using the involvement of academia in designing appropriate courses. Catherwood (2005) argues that Black Belts are "ideal" candidates as project leaders if they demonstrate high "technical/analytical competence" and high "leadership competence and organizational power".

The key attributes of Six Sigma Black Belts identified from a pilot study of UK manufacturers include: effective communicators, change agents, customer advocators, team builders, results-driven mindset personnel and positive thinkers (Antony *et al.*, 2007b). Similarly overcoming obstacles, attitude, logical thought process, communication skills, data driven, team experience and mathematics skills are key competencies identified by Pyzdek (2009). The

International Standard on Six Sigma (ISO13053) suggests competencies for a Black Belt as shown in Table 2.7. The levels mean – Levels are (0-Not needed; 1-Basic competence; 2-Proficient user; 3-Highest level of ability).

| **Skill** | **Black Belt** |
|---|---|
| Business perception | **2** |
| Computer literacy | **3** |
| Customer focus | **3** |
| Interpersonal skills | **3** |
| Motivational skills | **3** |
| Numeracy | **2** |
| Practical problem solving skills | **2** |
| Presentation skills | **3** |
| Process improvement experience | **2** |
| Process management Skills | **3** |
| Project management skills | **3** |
| Results driven | **3** |
| Six Sigma tools knowledge | **2** |
| Statistical skills | **2** |
| Statistical software use | **3** |
| Training skills | **3** |
| Coaching skills | **3** |

Table 2.7: ISO13053 Competencies for Black Belts

Black and McGlashan (2006) presents the results of a survey designed to help identify the desired personal characteristics of potential Black Belt candidates in organizations. In addition, an attempt was made to find out if there were differences in these desired Black Belt candidate characteristics according to industry, gender, and THE number of Black Belts already in each organization. The authors surveyed companies in a wide variety of industries in the USA that claimed to have implemented a Six Sigma program. The results of the study showed that several characteristics were more essential than others in considering potential Black Belt candidates.

From this review, competencies for a Black Belt are summarized in Table 2.8 and have been categorized into technical and inter-personal competencies. The set of competencies are also a minimum for a Master Black Belt discussed in the next section. It should be noted that some of these competencies for a Black Belt may be more appropriate to a Master Black Belt. For example, having a strategic understanding and coaching skills tends to be the role for a Master Black Belt rather than a Black Belt as will be discussed in the next sub-section.

Clearly, both technical and interpersonal skills are important competencies for the Black Belts as project leaders. An emphasis on interpersonal (or soft) skills of Black Belts working in SME's has been made by Timans *et al* (2012). Also, the competency or knowledge of the project leader or Black Belt will have an effect on the choice of tools and validation of data during each phase of DMAIC (Shri Ashok, Mukhopadhyay and Ghosh, 2013).

| Author | Competencies | Technical Skills | Inter-personal Skills |
|---|---|---|---|
| **(Wiklund and Wiklund, 2002)** | • Leadership | • √ | |
| | • change management | • √ | |
| | • learning aspects and self-knowledge | | • √ |
| | • supervision strategies | | • √ |
| | • statistics and finance and behavioral science | • √ | |
| **(Antony *et al.*, 2007b)** | • effective communicators | | • √ |
| | • change agents | • √ | |
| | • customer advocators | • √ | |
| | • team builders | | • √ |
| | • results-driven mindset personnel | • √ | |
| | • positive thinkers | | • √ |
| **(Byrne, 2003)** | • a clear understanding of their company's business strategies and objectives | • √ | |
| | • A strong process orientation | • √ | |
| | • A solid knowledge of and the ability to apply statistical/analytical tools and techniques | • √ | |
| | • Strong facilitation, teaching and team building skills | • √ | |
| | • Change management skills and experience | • √ | |
| | • Cross functional business and work experience | • √ | |
| **(Defeo, 2000)** | • Demonstrate management and leadership skills | • √ | |
| | • have a background in mathematics, statistics and analysis | • √ | |
| | • a basic understanding of the business process and of finance | • √ | |
| | • be a potential future manager or desire other advanced professional positions | | • √ |
| **Pyzdek, 2009 #319}** | • Overcoming obstacles | | • √ |
| | • Good attitude | | • √ |
| | • logical thought process | • √ | |
| | • communication skills | • √ | |
| | • data driven | • √ | |
| | • team experience | | • √ |
| | • mathematics skills | • √ | |
| **Catherwood, (2005)** | • demonstrate high technical/analytical competence | • √ | |
| | • high organizational power | | • √ |
| **Hoerl (2001)** | • statistical skills | • √ | |
| | • Organizational effectiveness skills e.g. team and project management | • √ | • √ |
| | • Meeting management skills | • √ | |
| | • able to present the results of projects and training skills | | |
| **Mitra (2004)** | • sound statistical education | • √ | |
| | • involvement of academia in designing appropriate training courses | • √ | |

Table 2.8: Black Belt Competencies

#### 2.9.4.3 Master Black Belt Competencies

In this section, a review of the literature that discusses competencies for Master Black Belts beyond those for Black Belts is presented.

As defined by Harry (1998), a Master Black Belt (MBB) is the overall Lean Six Sigma program leader or facilitator and therefore the focus of the MBB is on the deployment of the program.

Ladhar (2007) suggests that this role includes policy sponsorship, corporate resources management, garnering executive level buy-in, leadership awareness, forming and managing the corporate Six Sigma steering committee and providing the vision, goals and metrics.

According the Parr (2004), the Six Sigma community needs to work hard to maintain standards for the knowledge level or technical competence and experience of MBB's.

Consequentially, the MBB should have the competencies of coaching Black Belts in advanced statistics, finance and interpersonal skills (Wiklund and Wiklund, 2002).

Catherwood (2005) suggests the role of the MBB is to develop the implementation strategy, be accountable for success and obtain and allocate the necessary resources.

The International Standard on Six Sigma (ISO13053) suggests competencies for a Master Black Belt as shown in Table 2.9.

| Skill | Master Black Belt |
|---|---|
| Business perception | **3** |
| Computer literacy | **3** |
| Customer focus | **3** |
| Interpersonal skills | **3** |
| Motivational skills | **3** |
| Numeracy | **3** |
| Practical problem solving skills | **0** |
| Presentation skills | **3** |
| Process improvement experience | **3** |
| Process management Skills | **3** |
| Project management skills | **3** |
| Results driven | **3** |
| Six Sigma tools knowledge | **3** |
| Statistical skills | **3** |
| Statistical software use | **3** |
| Training skills | **2** |
| Coaching skills | **2** |

Table 2.9: ISO13053 Competencies for Master Black Belts

The levels are the same for a Black Belt but a value of 0 in the table indicates that, to fulfil the given role, a skill is not needed. It does not mean that the individual in the role will have no knowledge of that particular skill.

The above competencies of a Lean Six Sigma Master Black can be summarized as follows:

- Developing the deployment strategy
- Obtaining, allocating and managing resources
- Garnering executive buy-in
- Leadership awareness
- Creating the vision, goals and metrics
- Coaching Black Belts in advanced statistics

- Finance skills
- Interpersonal skills.

By way of comparison in a dissertation paper by Weyant (2009), a number of interpersonal competencies have been ranked statistically for Black Belts and Master Black Belts. The highest ranked attributes based on the mean score for Black Belts were: active/reflective listening, coaching, desire to mentor, confidence to mentor, patience and asking others for help. The highest ranked attributes for Master Black Belts were: active/reflective listening, confidence to mentor, coaching, desire to mentor, asking others for help and patience.

This suggests similar interpersonal skills for Black Belts and Master Black Belts. Interestingly, process improvement specialists and consultants must have interpersonal competence, theory-based problem solving capability, the ability to create a learning experience and the awareness of their own assumptions and models (Porras and Silvers, 1991).

#### 2.9.4.4 Influence Role of the Deployment Facilitators

The previous section discussed the competencies that the Master Black Belt or the deployment facilitator should display in their respective roles. Typical roles of quality professionals in general need to move from quality control to a leadership position with equal weight to the other department managers (Hooper and Devine, 2002). The role of these quality professionals must therefore contribute to strategic leadership to drive the firm's performance.

Likewise, Lean Six Sigma facilitators must hold a similar elevated position in the organization to ensure management commitment and buy-in. Champions are appointed to oversee a Lean Six Sigma deployment and these can be a Master Black Belt or a senior manager with knowledge of Lean Six Sigma (Pyzdek, 2003a).

Medina (2010) suggests that the role of the MBB must be accepted as a senior one throughout the company and the internal development of this role must be carefully managed to ensure the long-term health of Lean Six Sigma within an organization implying full commitment by the incumbent. In order to deliver on their tasks, the deployment facilitator needs to have a reasonable level of responsibility and authority in an organization since when it comes to ensuring Six Sigma delivers the promised benefits, a great deal rests on the shoulder of the facilitator and his appointed Black Belts. The ability of the deployment facilitator to influence the executive and other staff would be related to the seniority of the role they play. In practice, the role of the deployment facilitator or MBB may take a high level or a low level depending on whether the role is senior and influential or less senior, perhaps more analytical and less influential respectively. It is important to note that the degree of influence that the MBB has will be dependent on the perception of the seniority of this role to the employees (Medina, 2010). Whether or not the role of the Master Black Belt is full-time or part-time will dictate if the Lean Six Sigma project will be successful in the long-term (Catherwood, 2005).

The levels for the role of deployment facilitator derived from the above literature review appear to include those with department roles, business unit roles, operations improvement roles and leadership roles. Using a Likert scale of 1 to 5, these levels might be as shown in Table 2.10. Examples of these levels are developed further in Fieldwork phase 4 (Chapter 7).

| | Levels |
|---|---|
| 1 | Very low influence |
| 2 | Low Influence |
| 3 | Moderate Influence |
| 4 | High Influence |
| 5 | Very high influence |

Table 2.10: Possible Role levels of Master Black Belts

#### 2.9.4.5 Development of Research Question 4

Trained and experienced project leaders and deployment facilitators are critical to success. A competency-based perspective enhances the notion of training and experience. The competency of the Lean Six Sigma program facilitators and project leaders is important in impacting on organizational performance. Competencies can be divided into technical and interpersonal (or tacit in nature).

Based on the above and the literature review in sections 2.8.4.1 to 2.8.4.5, where a number of issues are raised relating to the personal competencies of project leaders (Black Belts) and deployment facilitators (Master Black Belts), the fourth research question has been developed, namely what are the personal competencies of the deployment facilitator and project leaders for the Lean Six Sigma deployment to be successful?

In fieldwork phase 3, a set of competencies are further developed for a Master Black Belt and Black Belt. In fieldwork phase 4 (Chapter 7), a set of competencies are further developed for a Black Belt based on the competencies in Table 2.8 and fieldwork phase 3. A set of competencies and influence levels are further developed for a Master Black Belt based on the review in section 2.9.4.3, Table 2.9 and fieldwork phase 3.

## 2.10 Common Critical Success Factors for TQM and Lean Six Sigma

### 2.10.1 Introduction

The purpose of this section is to compare critical factors for TQM success with those developed for Lean Six Sigma as shown in Table 2.6. A key point that arises in this review is that critical success factors are not different between Lean Six Sigma and TQM, this being recently suggested to be the case for all improvement methods by Naslund (2013).

### 2.10.2 Critical Success Factors of TQM

TQM has been deployed across many businesses and still exists today. A number of researchers stated some years ago that TQM may be either “dead” or “alive” (Filipczak, 1993; McManus, 1999; Oliver, 1996). Some more recent articles indicate that TQM is alive and well (Ahmad and Yusof, 2010; Dinh Thai, Igel and Laosirihongthong, 2010; Hongyi and Yangyang, 2010; Santora, 2009; Talib and Rahman, 2010; Tsuang, Tsun-Jin, Kuei-chung and Ming-yuan, 2009). Despite the high aims of promoters of quality management, the failures of organizations trying to implement TQM have been well documented (Brown, 1994; Cao *et al.*, 2000; Eskildson, 1994; Harari, 1997).

There have been mixed reactions to the success on businesses that have implemented TQM. Empirical evidence in establishing critical success factors for a successful TQM deployment has been completed by Saraph (1987), Powell (1995), Easton et al (1998), Sohal and Terziovski (2000), Brah *et al.* (2000), Motwani (2001), Sureshchandar *et al.* (2002), Sila et al (2002), Tsang and Antony (2001) and Baidoun (2003). Some objective evidence in identifying these critical success factors is provided in the papers by Sila and Ebrahinmpour (2002), Powell (1995), Baidoun (2003), Bayazit (2003), Zu *et al.* (2010), Sohal and Terziovski (2000) and Tsang and Antony (2001).

Powell (1995) suggests that TQM has a set of associated categories that are critical to the sustainability of long-term success of the implementation. These factors have been classified as measurable/tangible or tacit/intangible factors and are shown in Table 2.5.

The broad groups of factors used by Powell (1995) in his data analysis of TQM factors were derived from a review of the literature and the factors used in Deming's 14 points (Walton, 1986), the Juran trilogy (Juran, 1992), Crosby's 14 Quality steps (Crosby, 1979) and the Malcolm Baldrige Award criteria (George, 1992).

In the empirical research of Baidoun (2003), levels of success factors were ranked in 3 levels – tier 1, 2 and 3. The tier 1 factors are those that are absolutely essential for TQM to be successful. The tier 2 factors are those that a majority perceived to be of consequence in a successful TQM implementation. The tier 3 factors have the lowest impact.

Zu *et al.* (2010) investigates empirically that various cultures within the organizational cultural framework are important to deploying either TQM and Six Sigma. These cultures include a group culture (participation, teamwork, facilitator-type leader, people and commitment), development culture (creativity, flexibility, entrepreneurship-type leader, innovation and new resources) and rational culture (efficiency, task focus, achievement-type leader, goal orientation and competition). The fourth, hierarchical culture (centralization, order, administer-type leader, regulation, control) does not play a role in the importance of Six Sigma. This research further divides the second broad factor relating to culture and organizational support.

In a TQM study by Joiner (2007), it was also found that co-worker support and organization support moderated the relationship between TQM implementation and organization performance. For success, a culture of quality is critical to TQM (Gimenez-Espin, Jiménez-Jiménez and Martínez-Costa, 2013).

### 2.10.3 Development of Research Question 5

A key observation is that both TQM and Lean Six Sigma have been described as a philosophy of improvement involving leadership, culture, education, projects and data. Lean Six Sigma is suggested to have come about because of short-comings of Lean and Six Sigma separately but there is some contradiction with its similarities and differences with TQM.

Drivers and success measures for all improvement initiatives like TQM do not seem to be significantly different. However, Six Sigma and TQM differ because of the excitement generated by Six Sigma when it was launched, the financial benefits generated through projects and the training structure of Black Belts etc. However, there are overlapping tools used for both TQM and Lean Six Sigma. Critical factors for success for TQM can be divided in five broad categories as well and examples within each category do not differ significantly with Lean Six Sigma.

It can be argued that there are a number of common elements in any quality improvement initiative that are necessary for the success of the program in the long-term (Näslund, 2013). This is supported by a number of authors who have demonstrated that there are similar practices and success factors between Lean Six Sigma, Six Sigma, Lean and TQM (Andersson *et al.*, 2006;

Bendell, 2006; Cheng, 2009; Näslund, 2008; Talib and Rahman, 2010; Tsang and Antony, 2001; Zu *et al.*, 2010). From a review of the literature of TQM using a search category "critical success factors", examples of these factors are summarized in Table 2.11.

| **Broad Category** | **Example constructs from TQM literature** |
|---|---|
| Factors relating to leadership, structure, behavior and awareness of TQM | Top Management Leadership, support & Commitment; Quality Department Role; Visionary leadership; Allocating budgets; planning for change; aligning customer needs to processes; deployment across the business; standard methods of improvement |
| Factors relating to policies, culture, organizational support, communications and strategy | Open communication up and down; Continuous improvement culture, trusting environment; relationships with customers and suppliers, zero defects mentality, understanding internal customers and suppliers; positive attitude on quality; continuous flow of cross functional information and knowledge; employee empowerment; employee commitment; quality improvement awards; cleanliness |
| Factors relating to education, training and competency of the Quality experts | Education & training in quality, leadership & communication and statistics (SPC); middle management with skills in facilitating continuous improvement |
| Factors relating to project improvement teams and project management | Customer focus; Employee focus; process focused; Effective teams; integrating voice of the customer and supplier; use of stats tools |
| Factors relating to performance evaluations based on quality criteria, information systems, data and measurement | Quality data reporting; Supplier Quality Management; Product design; Service design; Measuring Cost of quality; Effective deployment of goals; performance measures; benchmarking; measurement systems; quality management systems; monitoring progress; problem solving based on facts; ongoing assessment of customer satisfaction |

Table 2.11: Examples of Critical Factors for Success of a TQM deployment

These examples are consistent with the examples of the broad factor categories for Lean Six Sigma presented in Table 2.5. It is important to note that the examples in Table 2.5 and Table 2.10 may overlap between each broad factor depending on the interpretation of the statement.

Based on the above discussion and the literature review all the sections from 2.6.2 to 2.9.3, where a number of similarities and contradictions are raised relating to TQM, Lean, Six Sigma and Lean Six Sigma, the fifth research question has been developed, namely what are the critical success factors or organizational competencies common to Lean Six Sigma and previous quality improvement initiatives like TQM?

In fieldwork phases 1, 2 and 4, insights are obtained about these similarities and differences between TQM and Lean Six Sigma during the face-to-face interviews, the in-depth case study and in an analysis of results from a National survey to test the model of a sustainable deployment of Lean Six Sigma. This fieldwork attempts to gain further insight and/or challenge current theory and practice.

## 2.11 Summary of Chapter 2

This literature review is presented in two parts. The first part defines the key concepts and performance outcomes of TQM, Lean, Six Sigma and Lean Six Sigma used in this research. One key point arising from this part is that, when an initiative is defined as a philosophy, there tends to be a blurring and overlap of the understanding of the key components of each initiative. Further, definitions of Lean Six Sigma have not shown to be different from the Six Sigma definition.

The second part of the literature review covers the key topic areas of the study in which the research questions are developed. A summary of the key points raised in this part are compared to findings from the fieldwork presented in chapters 4, 5, 6 and 7 and discussion and conclusions are presented in chapters 8 and 9.

# 3. Chapter Three: Research Framework and Methodology

## 3.1 Introduction

In this chapter, the research framework is presented followed by a description of the research methodology, a summary of the limitations of the data collected and the final section providing a summary of the chapter.

## 3.2 Research Framework

The research framework has involved two key areas – a comprehensive literature review phase and four fieldwork phases. The phases of this research followed chronologically are shown below in Figure 3.1.

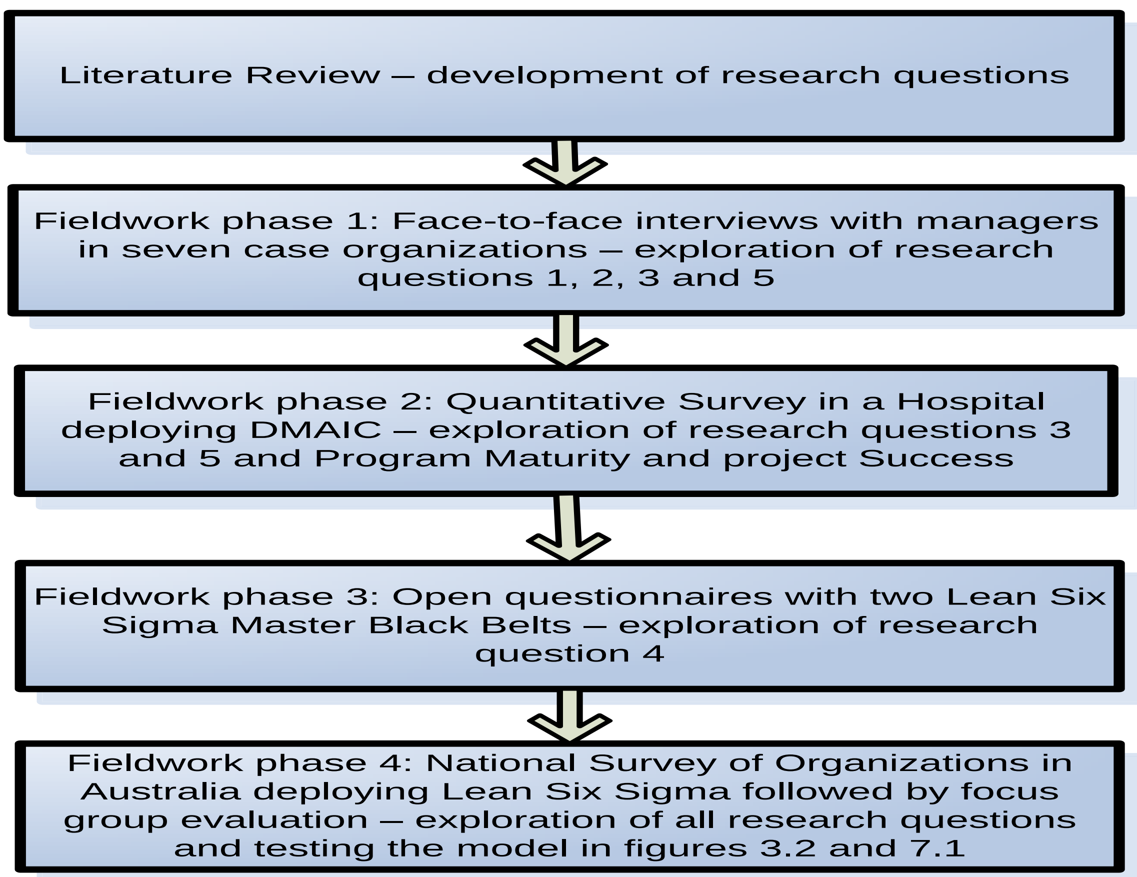


Figure 3.1: Phases of the Research

Five research questions have been developed from the literature review in Chapter 2. Specifically, section 2.6.6 presents the development of research question 1, section 2.7.7 presents the development of research question 2; section 2.8.3 presents the development of research question 3; section 2.8.4.5 presents the development of research question 4 and section 2.9.4 presents a review of research question 5. The research questions are listed below.

Research Question 1: What are the key drivers and success measures of a Lean Six Sigma deployment?

Research Question 2: What are the characteristics of the way Lean Six Sigma has been deployed and is it affected by organizational size?

Research Question 3: What are the competencies of an organization that result in the successful deployment of Lean Six Sigma?

Research Question 4: What are the competencies of the deployment leader and project leaders for the Leans Six Sigma deployment to be successful?

Research Question 5: What success factors are common between Lean Six Sigma and previous quality improvement initiatives like TQM?

Research questions 1, 2, 3 and 5 are explored in fieldwork phase 1 (Chapter 4). Research questions 3 and 5 are further explored in fieldwork phase 2 (Chapter 5). Research question 4 is explored in fieldwork phase 3 (Chapter 6). All research questions are further explored in fieldwork phase 4 (Chapter 7). A discussion of the results for each research question is presented in chapters 8 and the conclusions for each research question is presented in chapter 9.

Fieldwork phase 1 is presented in chapter 4. This involves face-to-face interviews using semi-structured questions with managers from seven organizations in Australia that have deployed Lean Six Sigma. The aim of fieldwork phase 1 is to gain insights into the drivers, deployment strategies, organizational competencies and benefits and challenges for Lean Six Sigma.

Previous research using semi-structured questions relating to Six Sigma has been undertaken by various authors (Antony *et al.*, 2007a; Jiju and Desai, 2009; Lagrosen, Rana and Max Rios, 2011; Ton van der, Jos van and Power, 2010).

Fieldwork phase 2 is presented in chapter 5 that involved an in-depth analysis of Lean Six Sigma in one of the seven organizations which is involved in Healthcare. The aim of fieldwork phase 2 is to gain insights into the relationship between critical success factors and performance measures for this case organization. This case was chosen as it was possible to gain full access to all senior managers and the willingness and research interest of the interviewee in the face-to-face interviews during fieldwork phase 1.

Fieldwork phase 3 involves the use of an open questionnaire with two Lean Six Sigma experts and is presented in chapter 6. The aim of fieldwork phase 3 is to gain further insights into the required competencies of a Master Black Belt and a Black Belt in Lean Six Sigma.

A key result from the fieldwork phases 1, 2 and 3 is the development of a model for the long-term sustainable deployment of a Lean Six Sigma (LSS) program. The model, presented in Figure 3.2 for convenience, relates two response variables (project success and maturity of the deployment) with four explanatory variables (organizational competence, personal competence of the LSS project leader, personal competence of the LSS deployment facilitator and the level of influence of the LSS deployment facilitator).

The organizational competencies for the model in Figure 3.2 have been selected from a combination of items developed in the literature review and fieldwork phases 1 and 2 and are presented in Table 7.2.

The personal competencies of the LSS project leaders for the model in Figure 3.2 have been selected from a combination of items developed in the literature review and fieldwork phase 3. These personal competencies are presented in Table 7.3. The personal competencies of the LSS deployment facilitator for the model in figure 3.2 have also been selected from a combination of the items developed in the literature review and fieldwork phase 3. These personal competencies are presented in Table 7.4.

Additionally, competence for the project leaders and the deployment facilitator are divided into technical and interpersonal based on the literature review and fieldwork phase 3. The levels of influence of the LSS deployment facilitator have been developed from the literature and fieldwork phases 1, 2 and 3. These levels are similar to the concept developed in the quality management field where a quality professional moves from with low influence to leadership positions with high influence driving change and better quality improvement systems. The levels of influence are presented in Table 2.10 and Table 7.5.

Fieldwork phase 4 involves a National Survey of Operations Excellence or Quality Improvement executives in Australian organizations that have deployed Lean Six Sigma and is presented in chapter 7.

The aim of fieldwork phase 4 is to test the model presented in Figure 3.2 (developed after fieldwork phases 1 to 3) and obtain objective evidence of what factors are critical for the successful and sustainable deployment of Lean Six Sigma. This represents a significant contribution to the theory and also provides, practitioners working in the field of Lean Six Sigma, a framework that will support the long-term sustainability of Lean Six Sigma.

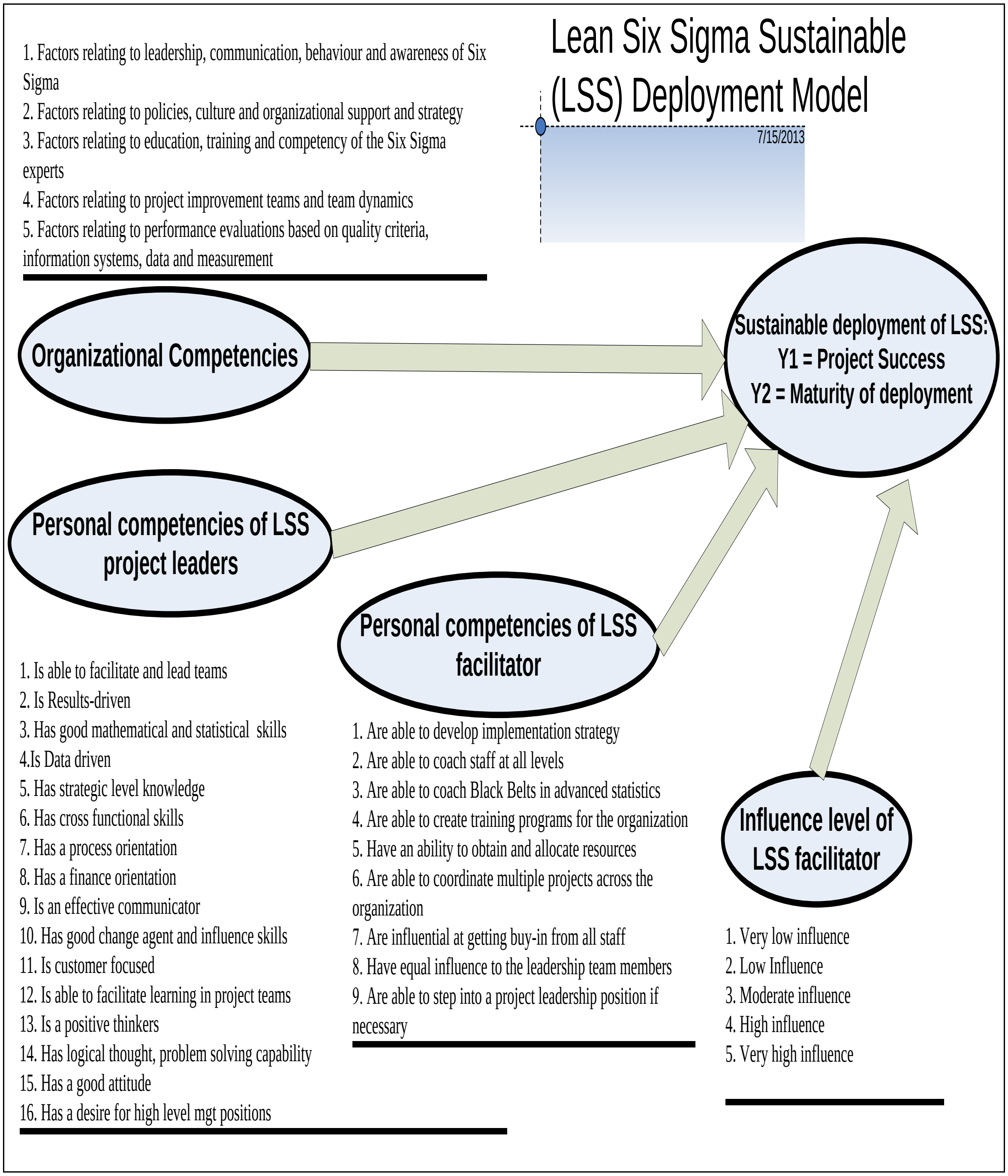


Figure 3.2: Lean Six Sigma Sustainable Deployment Model

The results of fieldwork phase 4 are cross-checked with comments during a focus group session. The people attending the focus group included respondents from the National Survey and other experts and practitioners in Lean Six Sigma. The focus group comments are presented in section 7.6.

## 3.3 Research Methodology

### 3.3.1 Introduction

This section provides a description of the research methods used. The first section covers the qualitative fieldwork phase. The second section covers the quantitative fieldwork phase. The third section covers why both qualitative and quantitative research methods have been used in this research.

### 3.3.2 Qualitative Fieldwork phases

#### 3.3.2.1 Fieldwork phase 1

For fieldwork phase 1 (Chapter 4), face-to-face interviews using semi-structured questions were conducted with senior managers from seven organizations including four in manufacturing (one large international, one large national, two small to medium-sized), one in healthcare, one in IT services and one in banking.

For each organization, interviews were conducted over a number of face-to-face sessions for a total of about eight hours with some material being provided in emails, telephone conversations and other written documents. In two of the organizations, secondary data was obtained from observations made during meetings of project improvement teams and management teams of the organization. In one organization quality audit reports were made available. This was possible whilst the researcher was involved as a trainer in these organizations.

The semi-structured questions were derived from the literature review in chapter 2 and from general discussions with Lean Six Sigma facilitators and practitioners known to the writer and experts in questionnaire design at Monash University with the intent of obtaining exploratory observations and answers to all the research questions. The semi-structured questions are presented in appendix A1. Previous research on Six Sigma using semi-structured questions were referred to (Antony *et al.*, 2007a; Jiju and Desai, 2009; Lagrosen *et al.*, 2011; Ton van der *et al.*, 2010).

The participants in the face-to-face interviews were senior managers who had various roles in Quality, Business Improvement and Operations Management. All these managers were familiar with continuous improvement including TQM, Lean, Six Sigma principles and the DMAIC methodology and were the facilitators of their organization's Quality improvement programs. Some participants were well qualified in business improvement, for example one with a Master of Business Administration and degree in Quality Management and others with qualifications in Lean Six Sigma at either Master Black Belt and Black Belt levels.

All participants had sufficient knowledge to answer the questions. Those participants qualified in Six Sigma demonstrated significant experience in Six Sigma at the project and strategic levels as did those not qualified in Six Sigma. Not all interviewees were trained in Lean Six Sigma.

The seven companies included the following organizations:

1. A small to medium-sized Australian assembler based in metropolitan Melbourne supplying parts to the automotive industry (Case 1)
2. A medium-sized division of a multinational organization based in country Victoria supplying castings to the mining industry (Case 2)
3. A large Australian Bank (Case 3)
4. A medium-sized manufacturer based in country Victoria supplying parts to the Truck industry (Case 4)
5. A large international company based in metropolitan Melbourne supplying parts to the automotive industry (Case 5)
6. A large international organization providing Information Technology services in Australia (Case 6)
7. A Hospital based in metropolitan Melbourne providing Healthcare services (Case 7)

The results of this fieldwork provide insights into the drivers, deployment strategies, organizational competencies and benefits and challenges for Lean Six Sigma.

#### 3.3.2.1.1 Selection of Organizations

The seven organizations were chosen from those that were known to have deployed Lean Six Sigma or variations of these initiatives. The selection came from a number of sources including those companies represented in a Monash University consortium to share best practice in Lean Six Sigma. This research was supported using internet searches of company websites and published literature naming companies using Lean Sigma. Once a company was identified by the research as using Lean Six Sigma, contact was made by phone, with a supporting email to the deployment facilitator or a point of contact provided through a personal contact, namely the members of the consortium. The email outlined the scope of the research and the intent of the research findings. Once a positive response was received, a follow up email was sent with an explanatory statement summarizing the research objectives and explaining the purpose of the research and the interview process.

Cases 1 and 2 were selected since the researcher had direct involvement in these businesses during training of a number of managers and team leaders to Certificate IV in Competitive Manufacturing, an Australian Nationally recognized course in Lean and Six Sigma (NTIS, 2008). This involvement for cases 1 and 2 was over approximately an 18 month period and it was possible to gain direct insights into the structure and deployment of their particular Lean Six Sigma programs. Case 1 was active with a Victorian-based best practice program, Innovations Insights (Insights2Excellence, 2008), as a host organization to demonstrate Lean principles. Case 3 was selected as it was well known as a leading Australian Bank that has deployed Lean Six Sigma. Case 4 was selected since the company was well known in the field of Quality improvement in the automotive supply chain. Case 5 was selected as the researcher had some personal involvement with this company in a Victorian Government based consortium of Lean practitioners (AME, 2008). Case 6 was selected as this company is well known in services in Information technology and had deployed Lean Six Sigma over a number of years. Case 7 was selected as the researcher had a personal knowledge of the organization applying the DMAIC methodology to some of their project improvements.

Cases 1 and 5 were essentially SME's in comparison with the other cases. Cases 1, 2, 4 and 5 were manufactures and cases 3, 6 and 7 were service providers. There are differences in organization characteristics but clearly all organizations have processes that need to be improved. All cases had challenges for their deployments and had to work at creating success outcomes.

The demographics of each case are shown in Table 3.1.

| Case | Industry sector | No. of Employees | Role (Lean Six Sigma Qualifications) of respondent(s) | Years active in Process Improvement |
|---|---|---|---|---|
| 1 | Medium sized manufacturer | 75 | Operations Manager and Production Manager (Green Belt) | 8 years |
| 2 | Multinational manufacturer | 140 | Continuous Improvement Leader (Yellow Belt) | 4 years |
| 3 | Large Bank | More than 3000 | Program facilitators (Master Black Belt and Black Belt) | 6 years |
| 4 | OEM International supplier | More than 300 | Managing Director (Master Black Belt) and Six Sigma Program facilitator/trainer (Black Belt) | 8 years |
| 5 | OEM supplier, local SME | 220 | Quality Manager (Green belt) | 5 years |
| 6 | IT Services | More than 1000 | Managing Consultant/internal advisor (Black Belt) | 5 years |
| 7 | Hospital | 200 | Director of Risk & Clinical Governance (DMAIC awareness) | 6 years |

Table 3.1: Profiles of Organizations used in Fieldwork

#### 3.3.2.1.2 Participants in Face-to-face interviews

For case 1, an interview was held with the Operations Manager who was trained as a Lean practitioner. Discussions were also held with the Production Manager. Observations were also made during the training of 12 team leaders, in Lean principles and the use of the DMAIC methodology as a project improvement tool to address customer concerns or business opportunities, by the researcher. For case 2, data has been gathered from interviews with the continuous improvement coordinator who was familiar with TQM and the Japanese quality circles and was also the Safety and Health representative. Observations were also collected from formal and informal meetings of managers and project teams. Observations were also made during the training of the continuous improvement coordinator and 34 other staff, in Lean principles and the DMAIC improvement methodology, by the researcher. The interviews for case 3 were conducted with two executives responsible for the facilitation and deployment of the Lean Six Sigma program across most divisions of the Bank. One interviewee was a Master Black Belt trained by her previous employer and the other interviewee was a Business Executive who was trained to Black Belt level in the Bank's internal training program. For case 4, interviews were conducted with the Quality Manager, who was a Green Belt in Lean Six Sigma trained by a key customer of this case. For case 5, interviews were conducted with the Managing Director who was trained and certified as a Master Black Belt with GE and an internal advisor who was trained and certified as a Black Belt by the American Society for Quality. For case 6, interviews were held with a Black Belt in Lean Six Sigma who was an internal consultant working on project improvement within the organization. He was recently trained in Lean Six Sigma. For case 7, interviews were held with the Director of Risk and Clinical Governance and the Head of Nursing. The former interviewee was familiar with DMAIC and TQM and held a Master's degree in Quality Management.

### 3.3.2.2 Fieldwork phase 3

For fieldwork phase 3, an open questionnaire was provided to Lean Six Sigma Master Black Belts (MBBs). One MBB had considerable experience in Banking and Finance and was also a psychologist and the other MBB was a consultant with considerable experience working across a broad range of industry sectors in Lean Six Sigma. The open questionnaire asked two simple questions "List the attributes or competencies of a Master Black Belt in Lean Six Sigma" and "List the attributes or competencies of a Black Belt in Lean Six Sigma".

The questionnaire aimed to provide insights and investigate any patterns regarding skills and personal attributes of Master Black belts and Black Belts in comparison with that observed from a review of the literature regarding personal competencies in section 2.8.4. The results from this open questionnaire are presented in Chapter 6.

#### 3.3.2.3 Analysis of Qualitative Data

In fieldwork phase 1, qualitative data was collected during face-to-face interviews using semi-structured questions. Although NVivo was considered as a tool for analysis, data were manually analyzed as there were only seven case organizations in total. Notes were taken during various meetings with the participants and key words were identified from these notes and summaries made.

A summary of the results of the face-to-face questions were referred back to the interviewees for comment. Adjustments were included. Keywords used to summarize the notes included drivers, success measures, deployment, projects, tools, strategies, training, critical success factors, benefits and challenges.

For two case organizations, qualitative data was also collected during project team meetings and attendance at management meetings by the researcher since these two organizations were being trained in Lean and Six Sigma using the DMAIC project methodology. In particular, project and Lean Six Sigma deployment benefits and challenges were also discussed with the trainees and recorded by the researcher.

For fieldwork phase 3, data was written into the open questionnaires by the two respondents. Contact was made with both respondents as a follow up to confirm the notes made. The comments and the competencies of Master Black Belts and Black Belts were summarized and appear in chapter 6.

### 3.3.3 Quantitative Fieldwork phases

#### 3.3.3.1 Fieldwork phase 2

For fieldwork phase 2, questionnaires were completed by 17 senior managers in the organization in healthcare, which was one of the seven cases reviewed in fieldwork phase 1. The 17 senior managers were selected by the Head of Nursing, who suggested that they understood quality improvement principles, TQM and were aware of DMAIC. These 17 staff included all the heads of departments in the hospital. The questionnaires were derived from the research work by Powell (1995) for TQM and the questionnaires are presented in appendices A2 and A3. Amendments to the constructs to suit the hospital were made in conjunction with the interviewee from case 1 in fieldwork phase1.

The results of fieldwork 2 are discussed in chapter 5 and provide further insight into what factors contributed to the performance of the Hospital and also insight into the development of a model for sustainable Lean Six Sigma deployment.

#### 3.3.3.2 Fieldwork phase 4

For fieldwork phase 4, a National survey was completed by Operational Excellence executives working mostly as deployment facilitators of Lean Six Sigma across a range of industries including Manufacturing, Health, Finance, Mining and Government.

This National survey was developed by the researcher in conjunction with Monash University academics who are expert in survey design and was piloted by 12 subject matter experts and practitioners in the field of Lean Six Sigma who have attained the level of Master Black Belt. Some amendments were noted following this pilot work. The survey instrument is presented in appendix A4 and results are presented in Chapter 7.

The survey was designed to investigate the relationship between the two factors: 1) deployment maturity of a Lean Six Sigma program and 2) the results of typical improvement projects being led mostly by Black Belts and various explanatory variables developed from the literature review and explored in fieldwork phases 1, 2 and 3 and shown in Figure 3.2.

#### 3.3.3.2.1 Sample for the survey

Lean Six Sigma has been deployed across most industries, recently in the construction industry (Al-Aomar, 2012), since every industry contains processes which are ripe for improvement and innovation.

The target audience for the survey was the Operations Excellence Manager deploying Lean Six Sigma in an organization. Organizations from all sectors were included including manufacturing, finance/banking, Healthcare, Government (public sector) and Mining. All these sectors have processes and potentially the deployment of Lean Six Sigma makes sense. A similar study using empirical evidence gathered using manufacturing, service, Government owned, privately owned large scale organizations was complete for organizations in Pakistan that have deployed Lean Six sigma (Zhang, Irfan, Khattak, Abbas, Zhu and Shah, 2012). The inclusion of the public sector in this research is consistent with the comments by Fernandez and Rainey (2006) that public sector organizations need to manage change in the same way to manufacturers and service organizations.

A representative sample of these managers was sought. Depending on the size of the organizations, these respondents may be qualified in Lean Six Sigma at various levels including the level of Master Black Belts and in some cases Black Belts or Green Belts. They also included roles such as Quality Managers, continuous improvement Managers, Business Transformation Managers etc. and they would typically be employed full-time in these roles. For the medium-sized organizations, it is expected that they are not necessarily full-time and not necessarily qualified to the level of Master Black Belt.

The sample could include consultants and/or trainers as some organizations do not employ Master Black Belts full-time. These consultants and/or trainers may have previously held a permanent or a contract position equivalent at a Master Black Belt level in one of the organizations deploying Lean Six Sigma. In this case, the respondents would answer the questions about the position that they held previously at the organization that employed them.

#### 3.3.3.2.2 Survey Process

Contact details of potential participants were obtained from various resources including the Australasian Association of Six Sigma Practitioners (AASSP, 2010), the Association of Manufacturing Excellence (AME, 2008) and networks of the researcher who currently works as a trainer and consultant in Lean Six Sigma in Australia. Before the survey was sent, a phone call was made to the participant confirming their interest in being part of the research. Once confirmation was obtained, the survey was attached to an email and sent with a research explanatory document to the participant. In some cases, a number of follow-up phone calls were necessary to check if they wanted to be part of the research and also prompt the participant to return the survey. Some potential participants were not able to be contacted and some just simply did not return calls.

Ninety-five completed surveys were received and based on an estimated 150 organizations in Australia deploying both the methodologies of Lean and Six Sigma, this sample represented 63% of the population. Of the remaining 55 organizations, about 15 were invited to answer the survey but did not.

For the remaining 20 organizations approximately, it was difficult to obtain details of Operations executives working in the relevant roles, especially the Utility companies and some Finance companies where access to personal contact details was difficult.

There are many companies in Australia that only have deployed Lean (mainly SME's) and these have not been sampled since they have not included Six Sigma in their deployment of their improvement initiative.

#### 3.3.3.2.3 Structure of the Survey

The survey instrument could be completed easily by clicking a box producing a "tick" symbol. Some information was typed in by the respondent. At the end of the instrument there was space to make "any other comments". The survey took approximately 45 minutes to complete. The first page provided an introduction to the research indicating the privacy and confidential nature of the instrument based on the University's ethics guidelines. The balance of the survey instrument included five sections labeled A to E as follows:

In section A, the respondent was asked to record demographic information including employment status; academic qualifications; qualifications in Lean Six Sigma; whether they are the deployment facilitator; the level of influence of themselves as deployment facilitator (or their perceived level of the facilitator if they are not); working time in Lean Six Sigma and how they were trained in Lean Six Sigma; and on the organization, including the industry sector and the size in terms of numbers of employees.

Section B included information on the organization's Lean Six Sigma deployment including data on the years the organization has been involved in Lean Six Sigma; how many projects the facilitator has managed; how successful each project was; the level of maturity of the deployment; Type of model used; Proportion of Black Belts spending more than half their time on projects; and what role they played.

Section C included information on the typical competencies of the Black Belts they work with or know. These are divided into technical and interpersonal competencies.

Section D included information on the competencies of the deployment facilitator. These are divided into technical and interpersonal competencies.

Section E included information on the level of organizational support for the various competencies - referred to as organizational competencies - which are essentially form part of a set of critical success factors.

### 3.3.3.2.4 Validity of the Survey Instrument

The initial survey was piloted by 12 Master Black Belts working as practitioners in Lean Six Sigma. A number of amendments were suggested including deleting some constructs that were not clear, for example "Self-awareness of Master Black Belts was confusing to some of these practitioners. If there were any complaints concerning this research, the respondents could contact the Standing Committee on Ethics in Research Involving Humans. They could ask to speak to the secretary or they could also write to the secretary at the following address: The Secretary, The Standing Committee on Ethics in Research on Humans, P.O. Box No3A, Monash University, VICTORIA 3800 at email **SCERH@adm.monash.edu.au**. Respondents completed the survey electronically and an explanatory statement accompanied the request. The survey was emailed back to the researcher.

### 3.3.3.2.5 Analysis of Quantitative Data

Data from fieldwork phase 2 was entered into Minitab and analyzed after the validity tests were completed using Cronbach Alpha (Nunnally and Peteraf, 1978) and ranking of constructs using Eta Squared values [Eta squared $=t^2 / [t^2+N-1]$]. Descriptive statistics and t-tests are also performed on the relevant data collected. The analysis appears in Chapter 5 (sections 5.3 and 5.4).

Data from fieldwork phase 4 was entered into Minitab and analyzed after validity tests were completed using Cronbach Alpha and a confirmatory factor analysis was also performed on the constructs listed in Figure 3.2. Graphical representations including Pareto charts, bar charts, box plots and scatter diagrams are used to present some of the results. Analyses were performed and t-tests and regression performed relating Lean Six Sigma Project Success and Program Maturity and various explanatory variables as described in Figure 3.2. It was also important to test if the constructs used are valid representations of the factors. This was completed using Cronbach alpha values and unreliable constructs would be deleted if the Cronbach alpha values were less than 0.7 (Nunnally and Peteraf, 1978). The analysis appears in Chapter 7, section 7.5.

At the end of the survey for fieldwork phase 4, respondents noted "any other comments" on Lean Six Sigma. General comments on deployment and specific points on maturity of the deployment were made. Direct quotes were noted and other text manually summarized using key words like leadership, culture, training, project management, data measurement, deployment, strategies, competencies, benefits, challenges and maturity. These comments provide further insights to the research questions and the model described in Figure 3.2.

### 3.3.4 Quantitative and Qualitative Research Methods

In this research, both qualitative and quantitative methods are used to collect data. The approach is both an explanatory and exploratory. For the organizations chosen, the aim is to seek to answer the exploratory, descriptive and explanatory "how" and "why" research questions based on multiple case studies (Yin, 2003).

The fieldwork at phases 1 and 3 is qualitative in nature. The fieldwork at phases 2 and 4 is quantitative in nature. Yin (2003) supports the use of both qualitative and quantitative sources since there can be rich information from member stories and objective data from surveys. This research explores the issues and describes and explains how and why Lean Six Sigma is deployed and sustained.

Cross-case analysis is used in fieldwork 1. The information from the cases attempt to provide a description of events or "the lived experience" from the participants who are Lean Six Sigma facilitators. O'Rourke (2005) applies cross-case synthesis to multiple cases to compare Lean Six Sigma deployment and implementation strategies.

For cases 1 and 2, there was an ongoing close working relationship with the interviewees on project work and training generally and therefore action research or the "Hanging around concept" of Dingwall (1997) has been used. This has allowed triangulation of data collection thereby ensuring reliability and internal and construct validity (Yin, 2003). There were numerous visits to each organization and as the trainer, it was also possible for the researcher to obtain secondary data on projects and sit in the various leadership team meetings to discuss the project outcomes and the success of the training and projects. This included being part of the internal communication meetings and in project review discussions.

Also, observations were made during the meetings held by project groups and steering committees for deployment. In this situation, multiple sources of evidence attempts to diminish any propensity for researcher bias (Yin, 2003).

Naturally, there can be a disadvantage to these extensive data collection sources - the volume may be overwhelming and lead to the ever-present danger of "death by data asphyxiation" (Eisenhardt, 1989), as well as privacy and confidentiality concerns.

However, Wilkins et al (1988) suggests that the multiple-case approach is highly preferable for building theory, as a hybrid form of case research, which included characteristics of hypothesis-testing research, such as sampling and controls while claiming to build theory. The resultant information obtained from each case in fieldwork phase 1 has been reviewed by the individuals that have been subjects in each case study (Yin, 2003).

In fieldwork phase 4, the research is about understanding how Lean Six Sigma works in organizations across different industry sectors including manufacturing, health, service, government and finance.

With the development of the model for sustainable LSS deployment, it attempts to test or challenge theory or it may also attempt to develop theory (Yin, 2003). The in-depth case presented in fieldwork phase 2 and the National

Survey (fieldwork phase 4) attempts to challenge the qualitative results and not jump to theory too soon (Eisenhardt, 1989).

These two quantitative surveys aim to allow generalizations about Lean Six Sigma sustainability and factors critical to a successful outcome.

## 3.4 Limitations of the fieldwork

In the qualitative fieldwork phase 1, the results are limited to data collected from the seven case organizations. A cross-case analysis is made but generalizations cannot be made (Yin, 2003).

In the quantitative fieldwork phase 2, the results are limited to data collected from one Healthcare organization in which only 17 participants were asked to respond to the questionnaire. This did not include the remaining staff in the Hospital nor did the research evaluate similar data from other Hospitals. The data collected is tested for statistical significance and there are statistical risks associated with the conclusions.

In the qualitative fieldwork phase 3, the results were only obtained from two experts in Lean Six Sigma and these experts may not be representative of the voice of Master Black Belts.

In the quantitative fieldwork phase 4, data collected from 95 organizations deploying Lean Six Sigma represented about 63% of the total. The number of Master Black Belts and Black Belts in Australia can only be approximated. There are a number of Lean Six Sigma practitioners registered with the Australian Organization for Quality (AOQ, 2010) and there are a number of members of the Australasian Association of Six Sigma Practitioners (AASSP, 2010), an association set up to assist in the development of Lean and Six Sigma in Australia. This fieldwork only obtained responses from deployment facilitators, that is, mostly Master Black Belts. There are a large number of Lean Six Sigma practitioners at Black and Green Belt levels working in manufacturing and service and these people were not sent the survey.

There are also a number of Lean practitioners who were members of the Association of Manufacturing Excellence (AME, 2008). Over the recent years, there has been a movement of Lean Six Sigma professionals across industries and within industries. For example, practitioners have been moving from manufacturing to Finance, Mining, Health and Government.

There are also quite a number of Black Belts within some of the larger International companies in Australia. For example, according to one of the respondents from a large organization in fieldwork phase 4, there were approximately 120 trained Black Belts working full-time or part-time in the business during 2011. These Black Belts were not sampled but collecting information from this cohort would provide rich information about the success of the deployment of Lean Six Sigma within the organization.

Finally, there is a significant turnover of Lean Six Sigma practitioners between organizations over time and this may create some confusion in interpretation of the results in fieldwork phase 4. Furthermore, Australian experience is examined and this may not apply to other countries.

## 3.5 Summary of chapter 3

In this chapter, the research framework is presented, the chronological order of the research is listed and the developed model for sustainable Lean Six Sigma deployment is presented. The research methodology section describes the qualitative and quantitative fieldwork. Finally, limitations of the fieldwork are presented.

# 4. Chapter Four: Fieldwork phase 1 (Face-to-face Interviews)

## 4.1 Introduction

This chapter presents the results of fieldwork phase 1 which involved face-to-face interviews using semi-structured questions with senior members of the organizations shown in column 4 of Table 4.1.

| Case | Industry sector | No. of Employees | Role (Lean Six Sigma Qualifications) of respondent(s) | Years active in Process Improvement |
|---|---|---|---|---|
| 1 | Medium sized manufacturer | 75 | Operations Manager and Production Manager (Green Belt) | 8 years |
| 2 | Multinational manufacturer | 140 | Continuous Improvement Leader (Yellow Belt) | 4 years |
| 3 | Large Bank | More than 3000 | Program facilitators (Master Black Belt and Black Belt) | 6 years |
| 4 | OEM International supplier | More than 300 | Managing Director (Master Black Belt) and Six Sigma Program facilitator/trainer (Black Belt) | 8 years |
| 5 | OEM supplier, local SME | 220 | Quality Manager (Green belt) | 5 years |
| 6 | IT Services | More than 1000 | Managing Consultant/internal advisor (Black Belt) | 5 years |
| 7 | Hospital | 200 | Director of Risk & Clinical Governance (DMAIC awareness) | 6 years |

Table 4.1: Profiles of Organizations used in Fieldwork

At the time of the interview, all these organizations had been active in process improvement using Lean and/or Six Sigma (using DMAIC methodology in projects) over a relatively long time given that Lean and Six Sigma were first adopted in Australia in the late 1990's by the automotive supply chain. The average number of years the organizations was active in Lean and/or Six Sigma was six. The reasons why these organizations have been selected is covered in section 3.3.2.1.1.

For each organization the following are presented:

1. An overview of the organization
2. Key drivers and deployment strategies
3. Critical factors for a successful deployment
4. Benefits and challenges of implementation

The section on the overview of the organization provides details of the organization and its background. The section on the key drivers and deployment strategies provides details of the key drivers for the Lean Six Sigma program and how the program was deployed and the model or methodology used. The section on the critical factors of a successful deployment provides details of the factors that the respondent suggests ensure success of the program or, in other words the organizational and personal competencies. The section on benefits and challenges provides details on the benefits to the organization and the challenges still facing the organization following deployment. The final section of this chapter presents a cross-case analysis of the seven organizations.

## 4.2 Case 1: First Tier Supplier to the Automotive Sector

### 4.2.1 Overview of Case 1

This case is a privately owned company that commenced operations in 1965 with a primary focus on manufacturing tools for the automotive industry. The company is innovative across all facets of its operations and this is particularly evident through the application of Lean design disciplines that have led to the company being recognized as a world-leader. The company employs about 80 people in Melbourne representing management, team leaders and operators. This organization had no previous evidence of the adoption of quality initiatives like TQM but the Japanese Quality Circles were adopted some years ago.

Strategically, the company has entered into a joint venture in China to ensure market share and increased sales in a globally competitive market. It was recently inducted into the Victorian Manufacturing Hall of Fame. As a Hall of Fame recipient, the organization was held in high esteem in the automotive parts supply business.

### 4.2.2 Key drivers and deployment strategies

A primary driver is the continued importance of reducing costs for product supplied to compete internationally given the significant downturn in the automotive sector. Lean was adopted in 2003 and the principles have focused around devolving responsibility to the team leaders and implementing a "Kanban" pull system (Womack and Jones, 1996) so that wastes are minimized including work-in-progress and overproduction. The automotive customers demanded this pull system using the Kanban approach and their level of inventory was managed well and kept to an optimum level.

Due to pressures from their automotive customer, a number of team leaders and operators were selected as trainees to be a part of an Australian Federal government initiative in a workplace training program in which participants were measured for competence under the Australian Federal Governments National Training Scheme (NTIS, 2008). The training was delivered at a level equivalent to "Lean Six Sigma Yellow Belt" (Harry and Schroeder, 2000). Trainees received training in Lean principles, the DMAIC methodology and various quality improvement and simple statistical tools.

The organization chose not to employ "Belts" as they are too "theoretical" (as stated by the interviewee). After the staff was trained to Yellow Belt level, they remained working full-time in operations. It was deemed important for the people working in continuous improvement, Lean or on DMAIC projects to be in the line management.

The training was considered successful as measured by benefits from ongoing continuous improvement projects. During the training, a number of DMAIC projects were completed, all delivering on relatively significant business cases of savings and cost downs.

The deployment strategy avoided focus on short-term fixes. Regular piloting in a selected department of an improved process occurred and, if successful, it was rolled out to the other departments.

### 4.2.3 Critical Success Factors

The two respondents, the Operations Manager and the Production Manager, were clearly committed to the improvement program. Both expect the same of their senior staff to coach and mentor team leaders through their own teams. Continuous improvement is clearly part of the company culture and this is displayed as attendees at the various Lean forums in Australia, for example the Association of Manufacturing Excellence (AME, 2008). As a member of the AME, this organization was able to be a host venue to show best practice principles in Lean and project work to many others across a wide variety of industry sectors, including manufacturing, Healthcare and service (Insights2Excellence, 2008).

The Operations Manager suggested that it was important not to brand the program under "Lean". Both interviewees stressed that it was important to make regular small changes as well as critical (breakthrough) process improvements.

Other factors were identified during interviews as key success factors:

1. The need to develop relationships with all stakeholders
2. Create an environment for change
3. Rewarding people for following the process rather than rewarding people for an outcome

4. Continually make improvements
5. Devolving power to the Team Leaders with a lot of open and honest discussions and
6. Allowing all the stakeholders to contribute to the solution.

The key stakeholders were the customers, suppliers, employees and shareholders and the interviewee suggested that optimizing value to each stakeholder was important in the success of the projects and the program overall. The company's environment was ripe for change due to the competitive nature of the automotive sector and the strategy of giving ownership to the team leaders to make quality decisions enabled this change to flourish.

### 4.2.4 Benefits/Challenges

A significant benefit to the business has been the freeing up of time for senior managers to focus on strategic issues and to be more proactive rather than reacting to various problem situations. There have been significant changes to the quality process in that team leaders are now part of the customer investigation process rather than just the quality department. The company has remained profitable in the light of increasing demands for cost reduction by their major automotive customers.

A challenge was the fact there were a number of inconsistencies in deployment of projects resulting from over enthusiastic people. The strategy was to get people to think about opportunities and get them to always follow the process methodologically. In particular, the Operations Manager stated that "continually focusing on the Lean philosophy and applying its principles and adopting DMAIC for problem solving" is critical to the future viability of the business. A weakness was that the company did "rest on its laurels" but was eventually reminded of their need to continually improve during a visit by one of the leading car manufacturers in Europe, who stated that they needed to change.

## 4.3 Case 2: Large Supplier to the Mining and Heavy Vehicle Industries

### 4.3.1 Overview of Case 2

This case is a Victorian-based division of an Australian leading global supplier of differentiated consumable and capital products to international markets and supplies products through five market focused divisions - Mining Products; Engineered Products; Rail; Industrial and Power & Cement. The case's management systems are certified to the International Quality Standard ISO9001:2008 and recent external audit reports have noted their excellence in continuous improvement.

### 4.3.2 Key drivers and deployment strategies

The key driver was international competition resulting in the need for significant cost reduction programs. The intent of the current initiative in Lean and Six Sigma was for a company-wide philosophy to be adopted as previous initiatives were not sustainable. The direction came from Head Office that the company needed to improve. This created some cynicism for the program initially but this faded after the training started and projects got underway.

About 120 employees were trained in Lean principles and the use of the DMAIC methodology to the level of Yellow Belt in Lean Six Sigma as part of an Australian Federal government initiative in workplace training (NTIS, 2008). The training purpose was to improve the capability of a majority of the workforce in the skills of Lean and DMAIC and to "Change the culture of the business".

Other quality initiatives had been introduced prior to Lean including the "Crosby Quality" program which primarily focused on improving work teams. According to the interviewee, this initiative was "not sustainable".

Lean and the use of the DMAIC methodology for projects have focused on supporting operational factors including product quality and yield, tooling upgrades and cost reduction to offset supplier increases in price. There was also pressure from the supply chain in that suppliers were “going under” and the need to manage a good flow of supply internationally was paramount.

There have been both internal and external forces that have driven the progress of Lean and DMAIC. Externally, it has been the need to reduce margins brought about by customer pressures. Internally, it was the need to involve the interests of all staff in projects.

### 4.3.3 Critical Success Factors

An important factor in the success of the program is the comment from senior management – “failure was not considered an option”. This is clearly a tacit factor and can be linked closely with leadership commitment and determination to succeed.

Another factor deemed to be critical was the high profile of the continuous improvement facilitator who was aware of all the Lean, quality and simple statistical tools and encouraged the use of the application of DMAIC. The facilitator was the sponsor for all projects and supported the project team presentations, which were attended by the executive.

The community spirit of the “need to continually improve” was deemed important and this was evidenced by slogans and other communication material around the site stating the company’s intention to reduce downtime and work-in-progress whilst improving safety.

Days off for successful projects resulted but monetary incentives were suggested not to be a critical success factor.

### 4.3.4 Benefits/Challenges

A clear benefit is that the company now has adopted “a way they do business”. Indirect benefits of the program have resulted in driving employee engagement through recognition programs involving lunches and prizes for employees.

A challenge is that organizational level performance indicators, like market share are not linked to Lean outcomes. A further challenge is the lack of standardization in trained employees using lean and statistical tools in the DMAIC phases.

It was suggested that the suppliers and customers should be involved in the deployment but this is difficult because of the inability of coordinating and scheduling training and joint projects.

## 4.4 Case 3: Large Australian Bank

### 4.4.1 Overview of Case 3

This case is a leading provider of integrated financial services including retail banking, premium banking, business banking, institutional banking, funds management, superannuation, insurance, investment and share-broking products and services. The key financial objective of the bank is to have total shareholder return in the top quartile of Australian listed peers over each rolling five-year period.

The strategic strengths of this organization are its branding, scale in the domestic market in Australia and diversified business mix. The organization is a long-standing supporter of community activities and organizations and this support is directed at a broad range of activities that bring long-term benefits to Australians and reflect community activities and organizations.

The Lean Six Sigma program facilitators interviewed included a Master Black Belt trained by a previous employer and a Business Executive who was trained in the Bank's internal program to Black Belt level.

### 4.4.2 Key drivers and deployment strategies

Lean Six Sigma has been deployed at this bank since around 2002 to support the key financial objective of the Bank. It was not called a Lean Six Sigma program but branded internally. TQM was not implemented previously. The initial Lean focus has evolved into selective use of Six Sigma to reduce defects in all processes, together with the development of a call center providing enhanced service offerings.

Lean Six Sigma was introduced as a large-scale change program and deemed a company-wide strategy, based on developing a sustainable capability across many staff. The Master Black Belt suggested that the company selectively uses Six Sigma techniques to achieve or preserve market leadership and they do not underestimate the impact of Lean techniques on competitive advantage.

The Bank's deployment structure consists of a central coordinating team and satellite teams based within business units. The business unit teams manage the projects within their business units. The central team provides training, methodology, communication, resource and strategy support. It also provides people to manage projects in those parts of the business without access to one of the satellite teams.

The view of one of the interviewees was that Six Sigma was the methodology that underpins all projects and Lean was a supporter. The second interviewee suggested that the Bank's Lean Six Sigma program was project-based being spread across the whole business and is viewed as an internal service whilst developing a sustainable capability across many staff.

The Bank's program has a significant portion of Lean tools being taught during training programs and appearing within the project improvement activities. The DMAIC methodology was combined with Lean tools since the view of one of the interviewees was that Lean could not solve all problems and perceived over-dependence on consultants for process improvement using Six Sigma. The Bank uses the DMAIC sequence even when doing primarily Lean projects because it lends structure to the project. Both interviewees would rate the Lean tools as the most commonly useful in the Lean Six Sigma toolkit.

Green Belt training was provided by an external party with a shared responsibility with the internal coach community. At the time of interviews, Black Belt training has been provided by an external party and it is likely to retain some external provision of courses. One-day overview training is also provided internally. Green Belts are trained in the 100's using a "boot camp philosophy" with a large number of Black Belts and Master Black Belts acting as coaches. The "boot camp" type approach involved more action and less theory through project activities. There is a significant investment in training but they have also made significant savings and have reduced costs.

In terms of Lean Six Sigma deployment, the Bank uses other financial organizations as benchmarks and one of the interviewees suggested that they were ahead of the opposition.

### 4.4.3 Critical Success Factors

Factors critical to success include the widespread development of capability of staff. All participants had to complete a project which had a business case. It is the success of the projects that have aroused interest.

Bottom-up implementation and embedding the skills into the culture of the Bank was deemed important. A weakness was the failure to build a pool of internal resources early and therefore rely on external consultants. Training was a critical component of employee engagement. Another success factor is the practice of committing staff and sponsors up-front to the full project and having them demonstrate commitment through investment in training and project time. The executive management supporting the program was deemed highly important.

The Bank's program has succeeded in being relatively homogenous across the organization, based on a strong central ownership and delivery of the training curriculum and an initial central coaching model. Many of the projects have necessarily focused on Lean principles to provide basic process clarity.

Coaching is important in which the Black Belt and Green Belt practitioners provide technical support, coaching and mentoring to project teams who are themselves trained in the basic Lean toolkit. The engagement model of forcing most Boot-camp attendees to have a viable project ready to commence before training is completed has greatly assisted in the overall success. High touch coaching model (typically 2 to 4 days per week of coaching time for the first Lean Sigma project in each business area) is key to the knowledge up-take of the project teams. The Bank also mandates the completion of a standard Lean Six Sigma 14 week project before considering candidates for Green Belt training and insists on a Green Belt certification before Black Belt training. There have been a few exceptions to this model and they have seen more effectiveness of the trained team members in terms of number and success rate of projects.

### 4.4.4 Benefits/Challenges

The high-touch coaching model, plus just-in-time training of project teams (that is teaching tools during the project work), together with the provision of a one-day overview for process owners, and a visibility of the program to the CEO and the executive members have all been aimed at achieving a wide-spread awareness and trust in the Lean Six Sigma approach. The Boot-camp has been very popular with business teams and has provided key insights into the impact of processes on customer service. Contributions come from personal commitment of staff supported by coaching styles of training with mandated training programs requirements.

The improvement projects have produced significant savings in the millions of dollars. At the time of the interviews, the program delivered over $51m in net benefit over the first 24 months of its operation, trained over 1,100 staff, provided improved operational processes for example reduced cycle times by 51% and delivered capacity and efficiency gains of over 30% across the portfolio of over 140 projects.

The management sees that some of the project teams going on to further process improvement, winning customer service awards, achieving greater sales conversion rates. Most of the projects have delivered sustained benefits.

For the Green Belts, a personal benefit was the Green Belt certification which was awarded after successful completion of training, at least one project and an assessable portfolio of competencies. For the Lean Six Sigma Black Belts, a certification was awarded after successfully completing at least two projects delivering at least $1m total benefits, demonstrating Six Sigma competencies and non-Six Sigma development and having at least one year service in a process improvement role post training.

The training costs are high and the plan was for internally driven training to reduce costs. Virtually all trainees use their knowledge after training but the frequency of the use of knowledge acquired reduces over time, where about 80% report regular use within one month of training, and around 25% report regular use after two years. A challenge was to stop the decline in use.

There is still a mix of skills sets and some trainees with past knowledge of other improvement methodologies tend to stick to what they know rather than using Lean and DMAIC.

The development of the "Program Every-Day" concept of continuous improvement that will eventually take the tools to all the staff and support them in the completion of numerous "micro-projects" to improve customer service every day is a significant challenge. A final significant challenge is to reduce the attrition of Black Belts moving to other employers.

## 4.5 Case 4: International Manufacturer in Australia supplying the Automotive Sector

### 4.5.1 Overview of Case 4

This case is one of Australia's leading manufacturers of advanced automotive parts and accessories. It has been a mature manufacturing facility which supports a diversified customer base and is cost competitive. Its excellent quality reputation is recognized both nationally and globally as indicated by the receipt of an external customer award.

The organization continues to focus on initiatives including enhancing the product portfolio offered to Australian customers, persisting to develop local expertise and continuing to support local and global customers.

### 4.5.2 Key drivers and deployment strategies

Customer pressure for exceptional product and service delivery and ensuring competitiveness was a driver for this company. Lean Six Sigma was implemented because it was deemed to be a natural resource for problem solving, the creation of defect free products and services and changing the culture. It represented a common "speak" within the automotive industry. One major customer had requested that Lean Six Sigma be deployed.

Also the organization needed to improve performance, which was measured at the organizational level by customer satisfaction and bottom line and at the operational level by defect rates.

When Lean Six sigma was implemented all employees had been trained to Green Belt level. There were no full-time Black Belts or Green Belts and the Six Sigma program manager had other operational responsibilities. Locally the company has allocated some middle management responsibility for Six Sigma. The strategy of deployment has been to set career planning based on the contribution to the Six Sigma program very similar to the General Electric model. Suppliers are trained to Green Belt level at no cost but on the premise that they undertake two projects for the benefit of both companies. Suppliers are deemed to be part of a value chain in which they are asked to drive efficiencies.

This organization had earlier implemented TQM. According to one of the interviewees, "the reasons TQM failed is because it was too generic and not project-focused and DMAIC is very different". The other issue was that training and mentoring and management support was not clearly defined. According to one of the interviewees, Six Sigma does not exclude anyone and it forces all staff to identify the real root causes of problems. One interviewee suggested that "TQM was known to just a few players whereas Lean Six Sigma is identified by all employees".

Lean Six Sigma is viewed both as a company-wide global strategy encompassing a framework of best practice and management principles and it has been implemented for particular critical-to-customer projects. Some of the elements of the program are incorporated into the way work is done using the DMAIC process in a proactive way, while some projects are reactive in the sense that they are initiated after a potential or real design or process problem.

The company has developed competency measures for their training and certification process. The financial savings from projects need to be independently confirmed prior to certification being awarded.

### 4.5.3 Critical Success Factors

Significant top-down support by the management team, buy-in from all employees, middle-management responsibility for Six Sigma, decision-making delegated to the team leaders and operators, personal responsibility attached to projects, good publicity for successful projects, working around change and good working relationships have all led to a successful implementation.

High performers are offered Black Belt training and behavioral change management training. Lean Six sigma is seen as an important qualification within the business for growth and rewards. The performance improvement plan has built in recognition and celebration of success, awards and congratulations by the Managing Director and all staff.

### 4.5.4 Benefits/Challenges

Benefits have included employee and customer satisfaction, financial savings using Return-on-Investment and sharing with customers, increases in cost avoidance programs, closer ties with suppliers involved in projects, enhancement of the culture, “ignited” senior management thinking, training that is linked to financial performance that has fostered employee engagement, and an empowered workforce.

The Lean Six Sigma program also allows collaboration with customers so the learning process is maximized. According to one of the interviewees “Real indicators would be long-term sustainability”.

Challenges include changing expectations of customers and third-party assessors to see evidence of continuous improvement, aggressive targets for exceptional product and service delivery, ensure ongoing executive ownership of process, costs of ongoing training, changing the skeptics view of statistics, reducing the attrition of experts, ensuring continual use of DMAIC methodology and defining KPI's for long-term sustainability, e.g. share price.

## 4.6 Case 5: Medium Sized Parts Supplier to the Automotive Truck Industry

### 4.6.1 Overview of Case 5

This organization is a leading manufacturer of quality electrical wiring harness, power and signal distribution systems for heavy transport, automobiles, military equipment, special purpose vehicles, motorcycles, marine craft, aircraft and fixed electrical plant. Established in the mid-1970s, this is a privately-owned supplier to many industries both at a first-tier and second-tier level and also servicing parts and accessories on demand. The company is recognized for its quality and reliability.

The organization has a Quality Management System integrating all facets of engineering, purchasing, and manufacturing, stores, dispatch and quality assurance to allow servicing of customers' ever changing requirements. It is an ISO 9001:2008 endorsed company.

### 4.6.2 Key drivers and deployment strategies

A key driver was customer pressure and the high cost of quality brought about by ensuring competitiveness. Further, there was an emerging threat from a larger organization. The organization had implemented TQM 10 years earlier but the impact was not quantified and so was deemed a failure. The operations demonstrated a commitment to a visual workplace through the use of Lean principles and practices by all work teams. DMAIC projects were common and involved training of most employees to Green Belt level by their main customer. Also, the quality system drives the program and the linkage of employee performance and this is consistent with their larger competitor. Suppliers were not involved in the program training or project improvements.

Training was "just-in-time" since Lean tools were explained to all staff during project improvements and the company's Kaizen blitz process. Projects were reported on during tool box talks and at month meetings.

### 4.6.3 Critical Success Factors

Success factors have included:

1. A very supportive continuous improvement culture
2. Company owners are fully behind the program
3. An open collaborative environment
4. The value of true organizational alignment from mission to operational performance indicators to desired results and
5. Quick wins through Lean tools and teamwork with all staff contributing to a positive work ethic.

The owners had created a culture of a connection as a "family" as the company was located in country Victoria and the staff both socialized with each other regularly out of work. As such, the company developed many competencies that provided a basis of an open and trusting environment. Financial rewards were not expected and personal recognition was the norm. KPI's were cascaded up and down the business and teams were aware of their KPI's for the work cell and how these linked to the business performance measures.

Quick wins were a focus but sustained improvements were developed through the correct use of the Lean and DMAIC tools.

### 4.6.4 Benefits/Challenges

Benefits included employee engagement and managing change in a fast-paced automotive environment. Challenges were the high cost of training, a clear understanding of the soft factors, collecting reliable data, inability to measure the program success, reducing the attrition of belts moving to other employers, the threat of continual cost downs requests from customers, using advanced statistics (including Design for Six Sigma) effectively, lack of resources, involving suppliers and finally maintaining employee engagement.

## 4.7 Case 6: Large International Organization providing IT solutions

### 4.7.1 Overview of Case 6

This is a large international organization providing Information Technology solutions to many small, medium and large manufacturers and services providers. This company deployed Lean Six Sigma in Australia in the early 2000s and at the time of the interview there is a large number of trained Black and Green Belts employed.

The interviewee for this case was a recently trained Black Belt in Lean Six Sigma.

### 4.7.2 Key drivers and deployment strategies

This organization had adopted a number of earlier Quality Management initiatives including TQM but these did not gain broad based traction. The previous improvement initiatives however did result in cultural impacts around better and more committed employee engagement. It was considered to be beneficial to have had already adopted TQM before their current Lean Six Sigma deployment.

The organization avoided labeling the program under Lean Six Sigma but referred to it as the "Business Improvement" program. The local executive had a strong financial focus for projects but there are many projects that do not necessarily achieve that degree of accountability. Lean Six Sigma is a company-wide quality improvement initiative but it has not been adopted by all parts of the business. The interviewee remarked that "it is not able to mandate to all parts of the business but it has not been difficult to sell the concept to each business unit". According to the interviewee "it would take a brave manager to say no". The program is "continually evolving" with more and more business units adopting versions of the program but all business units follow the DMAIC methodology. In fact, the take-up is not so much at a business unit level but at the project level.

To achieve certification the Black Belt trainees had to focus on improvement projects which resulted in significant bottom-line savings around $500,000. For certification of the trainees, the executive agreed to only support improvements which had savings that could be verified in the budgeted figures of the department that implemented the improvement.

The investment in training has been significant. Most of the training for this organization has been carried out through an internal corporate approved program. US based trainers at Master Black Belt level initially provided training to this Australian subsidiary. Local trainers were then trained by these Master Black Belts to provide further training. The competency-based training was highly structured with modules delivered over four weeks in classroom training format.

### 4.7.3 Critical Success Factors

Significant bottom-line savings and cultural impacts were deemed to be relevant to success. There were realistic indicators that were monitored in budgeted figures regularly. The interviewee stated that "a few very senior people are committed to see it work including the CEO and Vice President of this organization". The senior leadership was also prepared to get actively involved in the program through various steering committees.

The rigorous training program was included as part of the staff development program and this was deemed a critical factor. There were a number of highly qualified and experienced Master Black Belts facilitating the program, many of whom were recruited externally and appointed as permanent staff and not used contractors.  This was deemed important for building internal capability.

A factor that appeared to hinder the success of the deployment was that some of the Black Belts had a cookbook approach to the DMAIC methodology and lacked the ability of an in-depth statistical analysis of the data. According to the interviewee "this is changing with the internal Black Belt certification process in place currently".

A factor enhancing the success was that most business unit managers lead the change and this gives "buy-in at the highest level" for each business unit.

### 4.7.4 Benefits/Challenges

Some of the projects have resulted in significant benefits including reengineering of processes, elimination of non-value added steps, realignment of work to optimize resources and the development of new approaches to providing service.

The program has a strong process focus but many trained staff lack full understanding of process capability. An example of this was the misunderstanding of customer requirements resulting in a poor understanding of "process capability".

There was a fair degree of "cynicism" around the program initially since some of this organization's clients had adopted versions of Lean Six Sigma and it had failed. Also, if a project was labeled a "business improvement" project it was certain to be passed at the Define phase of DMAIC by the executive and this created some further cynicism for the program.

Cultural impacts are difficult to measure. However, there is recognition that there have been some "soft" benefits, by providing an improved sales process. According to the interviewee, for example, the sellers of this company's products and services have an increasing amount of time to sell (service time) and on reducing the complexity required to get proposals out, orders into the system, solutions delivered and billed. There is a strong focus on data and measurement and this has resulted in the way the organization "does business".

A further challenge was that some Black Belts, managers and project sponsors wanted to move to the Improve phase of DMAIC too quickly without fully exhausting all the work required in the first three phases. This was about getting short-term answers rather than sustainable outcomes. According to the interviewee "it is getting a better balance towards sustainable benefits as the business improvement program is deployed further throughout the organization".

Further challenges are to maintain consistency of Black Belt competency, focusing on sustainable projects and consistency of outcomes of deployment across the business units.

## 4.8 Case 7: Hospital

### 4.8.1 Overview of Case 7

This case is an acute tertiary teaching hospital based in Victoria. The core business is described as healthcare, teaching and research. The Hospital introduced a quality systems approach several years ago with some success. The aim is to be patient and consumer-focused by improving overall quality of care and safety, achieving operational efficiency and effectiveness and maintaining business continuity. The objectives include meeting the needs of patients and consumers, managing risk through preventative methods, measuring, analyzing, implementing change and monitoring and evaluating outcomes.

TQM was adopted previously during the 1990's but, according to the interviewee, was "compliant-focused through auditing and assured quality whereas Six Sigma is outcome-driven allowing decision making, setting of priorities to ensure appropriate funding, measuring outcomes thus feeding back into the system to improve the process".

The interviewee had a role as Director of Risk and Clinical Governance but had no formal training in Six Sigma but was a researcher and was familiar with the DMAIC Six Sigma methodology, including Quality tools such as statistical process control, root cause analysis and data analysis in solving problems.

### 4.8.2 Key drivers and deployment strategies

Delivering safe, appropriate clinical care is clearly the main objective of an acute hospital. Other major functions include implementing processes that ensure equitable and timely access into the clinical services of emergency, outpatients and surgery and the appropriate safe and timely discharge back to the community. The principles of supply chain management fit well with patients, and information about patients, navigating the complex health care service from first contact, the continuous receipt of numerous services, to a timely and safe discharge.

A key driver for improvement is to maintain government funding. The Victorian Government had introduced a new funding approach based on performance during the 1990's in which hospitals would be sanctioned if targets for waiting lists and emergency department measurements were not significantly improving. This forced a new thinking during implementation of the DMAIC methodology. However, the hospital introduced root cause analysis as a tool for teams to use to investigate problems in order to create a project improvement culture. If performance measured by defect rates is poor, e.g. an incorrect surgery, there is a significant impact on risks to patients and long-term competitiveness.

The need to implement the DMAIC methodology across the patient pathway was based on the awareness that large amounts of data were available but not being used throughout the hospital and operational metrics needed to be developed to determine how well the hospital was doing, for example patient throughput and emergency care in order to obtain appropriate Government funding.

This hospital benchmarks throughout the world with equivalent hospitals. Process improvement teams are common, for example in patient discharge planning. Key projects were based on the DMAIC methodology and focused across all departments. Basic training in data analysis has been provided by the interviewee. Awareness training has been undertaken on quality generally to the executive and nursing and other specialists. The Hospital's program model was presented to and accepted by senior representatives at Europe Health Care conference to demonstrate that data is the critical component of delivery of success factors for the hospital. For example, if performance is significantly poor there is a significant impact on patients and competitiveness and long-term sustainability. The project teams use DMAIC indirectly at a level that is acceptable to the staff of the hospital that is, using low levels of statistical analysis. It was recognized that this level could be made more detailed using external Six Sigma specialists. The focus however, was training staff on basic Statistical Process Control methods and data analysis. Awareness training was performed on quality generally and data analysis to the executive and nursing and other specialists.

### 4.8.3 Critical Success Factors

The hospital needed to move from silos to cross-functional and multidisciplinary project improvement teams so that patients are viewed as part of a system rather than separately by doctors, nurses, social workers etc. It was also important to have linkages between patient assessment, diagnosis and treatment.

Another factor critical to the success of Six Sigma is the drive given by the interviewee, who has a strong background in quality management, education research, statistical awareness, facilitation and strategic influencing skills. In particular the interviewee had research experience in quality management and Six Sigma applications in the healthcare industry in the US. Benchmarking other hospitals to remain competitive and innovative is critical. Recognition was important and the hospital executive up-take has contributed to the success.

The setting up of Process improvement teams in the hospital was critical, for example, for discharge planning. It was deemed important to have team member recognition process that is, one that recognized team members for valuable effort.

Continued use of the DMAIC methodology to solve problems was deemed to be critical to maintain a competitive advantage since the hospital competes for patients and funding based entirely of performance improvement, for example, if the hospital moves from 6000 to 8000 successful surgeries without exceeding the budget then funding would be increased.

### 4.8.4 Benefits/Challenges

The program has shifted how nurses conceptualize clinical cases and nurses and other staff are empowered by using a common language. The program has created a culture of regularly presenting performance data to board executives who direct attention to managers for strategies for improvement and accountabilities. Some significant benefits have also included general staff satisfaction through employee empowerment at the organizational level and significant improvement in service delivery, reduction in surgical waiting lists and reduction in waiting times for outpatients and easy access to emergency at the operational level.

All department managers have not embraced their responsibilities within the program yet but senior managers and executives are cooperative. There are masses of data available for analysis but not always used well.

The CEO is not yet on board with the initiatives so this is a key challenge. The attrition of staff trained in DMAIC and quality presents a problem and there is a perceived significant demand on people’s time by some staff.

There was a need to reinforce knowledge of Six Sigma throughout the organization and more recognition of, and continuing the approach to, consistency of language was also deemed important. There was a need to deliver results to the newly appointed executives who created a challenge to everything including Six Sigma. If performance was seriously a problem for example, deaths following emergency cases, then the pressure to deliver was significant.

There is a need more formal training of Six Sigma particularly more use of SPC and Design for Six Sigma in the internal supply chain, for example for critical care patient paths and to analyze the linkage and success factors between services. There is a need to bring the service providers into the methodology but this was deemed to be a challenge. High staff turnover presents a threat to the Six Sigma program. The culture in the hospital is generally amenable to large shifts in initiatives.

## 4.9 Cross-Case Analysis

### 4.9.1 Introduction

In this section, a cross-case analysis is presented. A number of insights can be drawn with respect to key drivers, deployment strategies, organizational and personal competencies and benefits and challenges of Lean Six Sigma from the fieldwork presented in this chapter.

### 4.9.2 Overview of cases

Cases were from the manufacturing, banking, IT and healthcare and included organizations that were privately-owned and publically listed on the Australian stock-market. All cases had been operating for many years with strong market presence, strong branding and unique products and/or service. The deployment facilitator(s) for all cases were very committed to continuous improvement and had considerable experience in quality improvement, Lean and/or DMAIC and/or Six Sigma, although there tended to be more experience for those in manufacturing but higher tertiary qualifications for those in the cases in Healthcare, IT and Banking. Many of the cases deployed previous quality initiatives like TQM and quality circles without success mainly because improvements were not able to be financially measured.

### 4.9.3 Key Drivers and deployment strategies

There is pressure on manufacturers, especially SME's in the automotive supply chain, to continually reduce costs and focus on improvement using methodologies like Lean Six Sigma and involve the supply chain (suppliers and customers) in their improvement activities. The larger organizations have pressure to deploy continuous improvement due to local and international competitive pressures although with larger financial resources these organizations are more adaptable to change and deploying improvement initiatives. SME's tend to look for assistance from Federal Government funding with respect to training of employees in Lean Six Sigma. The Healthcare case is driven to improve in all their services as a way to demonstrate innovation and cost reduction, which is usually rewarded by increased State Government funding. The Bank's focus, on the other hand, is about improving customer service.

A driver for all cases was to develop capability and empower employees across the organization. For the Bank and the case in IT, it was about creating a culture of improvement and with the manufacturers it was about enhancing their current improvement culture.

The training approach for employees in Lean Six Sigma has varied with the larger cases allocating more financial resources to training using external consultants and trainers and the SME cases obtaining support from Federal Government assistance. The Bank implemented a unique approach to training using a "Boot Camp" type approach which involved more action and less theory through project activities. The larger cases tended to certify to at least Green Belt level in Lean Six Sigma. For some of the manufacturers training included suppliers.

Deployment tended to be top-down for the larger cases and bottom-up for the SME cases. For the SME's, the deployment was across the organizations but piloting in selected departments first was important. For the Bank and the large international manufacturer, the deployment was a large-scale change program but for the case in IT, Lean Six Sigma was only deployed in some divisions but the intent was across all businesses.

All cases opted to not brand the program under Lean Six Sigma and all cases had facilitators with high influence across their organizations and these roles were supported by the respective leadership teams. For Case 1, the

Operations Manager opted to spread the quality responsibilities to Team leaders, who have high influence at a department level.

DMAIC has been the standard deployment model across all cases except that the quality management, Lean and statistical tools used in each phase have varied. The cases in manufacturing have tended to use simpler tools in the DMAIC phases whilst the larger manufacturers have used a mixture of tools ranging from simple to advanced statistical tools like “Design for Six Sigma”.

The case in healthcare recognizes the need to apply these advanced tools. The order of the initiative used varied across the cases with Lean starting in some cases and Six Sigma being deployed first in others. There did not appear to be any effect on the ongoing practice no matter what order was used.

Some cases tended to leverage successfully off previous quality initiatives, like TQM, Crosby’s 14 points, simple root cause analysis and the Japanese Quality Circles initiative. All cases had a project focus and each project was measured at an operational level in a number of ways, including quality, process efficiency, responsiveness and project schedule adherence. These measurements, at the operational level were the way that the deployment was measured for success. For the Bank and IT case, the project success was linked to overall profitability, being an organizational success measure.

Tables 4.2 and 4.3 on pages respectively summarize the key drivers and deployment strategies across all cases 1 to 7. In Table 4.2, the ticks (√) mean that the key driver applies to this case.

### 4.9.4 Critical Success Factors

A critical factor for all cases was the importance of commitment from the leadership team and the need to create a structure for continual improvement, like strategically selecting candidates for training in Lean Six Sigma. For all cases, it was important to ensure leadership down the line at the supervisor level. For the private companies there was demonstrated enthusiasm from the owners as it was their livelihood. There was importance placed on the need to ensure that continuous improvement was part of the company’s culture and not seen as add-on when customers complain. This was very important for the cases in manufacturing. Rewarding and empowering staff was deemed important although not as important for the case in IT. Collaboration across the supply chain with suppliers and customer was deemed important by the cases in manufacturing.

Embedding the improvements in a Quality Management System (like ISO9001) was deemed important for the cases in manufacturing. Coaching and mentoring was deemed important for the larger cases due to the sheer size of the training cohorts. For all cases, building capability across the organization was a strong focus and deemed critical. For all cases, the availability of data was critical for a project to be successful. Data for the case in IT was not always recorded and/or available.

Rewards and recognition tended to have more relevance for the manufacturers rather than the service companies since there was more pressure to stay profitable. Employee engagement was clearly seen for the SMEs. Also employees became more motivated following training. This was evident for the Bank and both SMEs. The habit of using CI tools on day-to-day basis was critical for both SMEs. All these factors help in sustaining the momentum and benefits from LSS in the long-term.

Examples of organizational competencies developed from this cross-case analysis are presented in Table 4.4 using the broad factors developed in Table 2.4 and the comments in this chapter. In particular, these specific competencies add to the competencies already developed in the literature review.

### 4.9.5 Benefits and Challenges

For all cases, there was a heightened awareness of the need to continually improve resulting in employees being more empowered to make changes. However, this was less visible for the case in IT.

For the Bank, there was significant savings resulting from projects which in turn resulted in a more competitive market position. Nevertheless, for all cases there were significant gains from projects measured by either - quality, process efficiency, responsiveness or project schedule adherence. Other project success measures were noted included empowered employees and cultural impacts. For the manufacturers there was more collaboration in the supply chain, and for two of the manufacturing cases, customer awards were deemed a benefit of their programs.

For all cases, a key challenge was the need to keep trained Lean and Six Sigma experts employed with their organization, that is, not to leave employment and move to a competitor or another organization. Another key challenge for all cases was the need to be consistent in the ongoing use of DMAIC and sustaining gains and not slipping back into "old" habits of "jumping to solutions".

The case in IT was having difficulty in deploying the program across all divisions mainly because of the sheer size and complexity of this international organization. A challenge for the case in Healthcare was the ongoing involvement of suppliers, for example surgeons and other professional staff. A challenge for all cases was to ensure competence in the use of Lean and Six Sigma tools over time. For the Bank and the case in IT, ensuring all new employees were aware of the need to always improve was an ongoing challenge.

Finally, a challenge for all cases was the need to always ensure that the organizations maintained their strategic direction and therefore their ongoing commitment to Lean and Six Sigma to ensure maturity.

Tables 4.5 and 4.6 summarize the Benefits and Challenges by Case.

| Key driver & Success Measures | SME Automotive Supplier | Large Supplier to Mining & Heavy Vehicle Industry | Bank | OEM Supplier International | OEM Supplier to Truck Industry (SME) | IT Service | Hospital |
|---|---|---|---|---|---|---|---|
| Profitability or Saving | √ | √ | √ | √ | √ | √ | √ |
| Competitive Advantage | √ | √ | √ | | | | √ |
| Cost reduction | √ | √ | √ | √ | √ | √ | √ |
| Customer Satisfaction | √ | √ | | √ | √ | | √ |
| Maximize Shareholder Value | | | √ | | √ | | |
| Process Efficiency | √ | √ | √ | √ | √ | √ | √ |
| Process Quality | √ | √ | √ | √ | √ | √ | √ |
| Productivity | √ | √ | √ | √ | √ | √ | √ |
| Market Share | | | √ | | | | √ |

Table 4.2: Key drivers and Success Measures by Case

| **Deployment Strategies** | **SME Automotive Supplier** | **Large Supplier to Mining & Heavy Vehicle Industry** | **Bank** | **OEM Supplier International** | **OEM Supplier to Truck Industry (SME)** | **IT Service** | **Hospital** |
|---|---|---|---|---|---|---|---|
| Enterprise level as well as business level | Company-wide with Lean; Team leaders with DMAIC expertise only | Company-wide with Lean; Team leaders with DMAIC expertise only | Company-wide; central coordinating control; Internal branding of program | Company-wide initiative | Company-wide with Lean; Team leaders with DMAIC expertise only | Company wide deployment, with regional management; Internal branding | Across all of patient access |
| Consistent use of DMAIC | Used DMAIC in some projects | Used DMAIC in some projects | DMAIC used across all projects and is the company wide standard | Used DMAIC in all projects | Used DMAIC in all projects | DMAIC in some areas | DMAIC look alike |
| Use of simple statistical and lean tools | Common across projects | Common across projects | Yes, common | Common across projects | Common across projects | Exists | Quality tools |
| Lean first then Six Sigma | Lean then DMAIC | Lean and Six Sigma Concurrent | Lean tools being taught | Six Sigma first then DMAIC with Lean | TQM first then Lean and Six Sigma concurrently | No | Lean not known |
| Use of advanced statistical and lean tools | Low use, facilitator not experience in advanced statistics | Low use, facilitator not experience in advanced statistics | Limited | High use due to facilitators being GE Trained | Low use | Common | No |
| Leverage off previous deployments of | Previous involvement with Quality Circles | Ongoing involvement with Crosby 14 points | Previously deployment of TQM & | Long history of TQM deployment | Continuous improvement culture exists for many years | Previously deployed but no traction financially but | Root Cause analysis introduced |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| improvement | | to zero defects | Continuous Improvement | | | developed a culture of continuous improvement | throughout hospital; TQM existed partly |
| Use of a Belt infrastructure | Yellow Belt level only | Yellow Belt level only | Yes | All levels due to International effect | White Belt and 1 Green Belt | Yes | No |
| Project Focus | Project Teams for all improvements | Project Teams for all improvements | Six Sigma underpins all projects with lean as a supporter | Project Teams for all improvements | Project Teams for all improvements | Strong financial project focus | Cross functional and multi-disciplinary teams |
| Enterprise-wide focus | Local to only site | Launched nationally | | Launched international | Local to site | | |
| Lean only projects | Complimented DMAIC projects | Complimented DMAIC projects | | Not applicable | Quick wins through some lean projects | | |
| Involvement of suppliers in improvements | Involving suppliers was their culture due to ISO9001 | Difficulty in getting suppliers improved | No | Always involved suppliers in improvement projects | Always involved suppliers due the strong supply chain network | No | Part of strategy to link to l suppliers |
| Training strategy | Government funded training in Certificate IV | Government funded training in Certificate IV | Boot Camp style; certification as Belts | Internal training of Belts | Awareness training in DMAIC and lean by Quality Manager and major customer | Coordinated in US with some local training at business unit; certification as Belts | All training performed by respondent; no belts |
| Life Cycle stage of deployment | Developing quickly | Developing quickly | Developing quickly | Developing slowly | Developing slowly | Continually evolving | Developing slowly |

Table 4.3: Deployment Strategies across the cases

| CSF | Suggested construct from literature | SME Automotive Supplier | Large Supplier to Mining & Heavy Vehicle Industry | Bank | OEM Supplier International | OEM Supplier to Truck Industry (SME) | IT Service | Hospital |
|---|---|---|---|---|---|---|---|---|
| 1 | • CEO leadership & management commitment<br>• Line management drive<br>• Continuous Improvement champion with high influence | Strong commitment from general manager; Line managers and supervisors manage projects; CI champion with moderate influence; facilitator succession planning in place | Moderate involvement from Leadership team, Strong commitment from Operations Supervisor; Appointment of a CI champion with high influence | Strong leadership across the banking units<br><br>Champions with high influence | Strong leadership support from MD, who was a trained Master Black belt from GE, Responsibilities down the line for improvements<br><br>Nominated LSS champion with high influence | Strong commitment from owner on continuous improvement for many years; Quality Manager (interviewee) was a Green belt and nominated improvement manager responsible for ISO9001 with high influence | Sponsors drive the program and projects at the business level; Champions in each region at average influence | Very high influence level of leadership and interviewee; Strong drive through nurses at each department |
| 2 | • Individual branding of program<br>• Reward process<br>• Continuous improvement as part of culture<br>• Improvements shared with | Conscious decision to not brand the program with words Lean or Six Sigma; Project teams were rewarded on success; | Branded under continuous improvement; Staff rewarded for successful projects; suppliers part of improvements | Internal branding<br><br>Continuous improvement not adopted previously<br><br>Employees empowered to | Improvements always shared with suppliers; Some employee empowerment; Lean Six Sigma has been branded clearly across the | Lean or Six Sigma not referenced but continuous improvement is the banner; A strong culture of continuous improvement led | Internal branding<br><br>Continuous improvement part of culture from TQM | Internal branding; strong root cause analysis process across the hospital; nurses knew they could makes changes owned the |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | suppliers and customers<br>• Employee empowerment | Customers were also brought into the improvement due to automotive demands; Teams were empowered to make changes within budgets; CI was an expanding culture in the business; never rest on ones laurels | | make changes | business; Trusting environment; Common language | by the owner; Moderate level of employee empowerment | | problems |
| 3 | • Consistency in training in DMAIC<br>• Funding training<br>• Coaching process<br>• Building skills across organization<br>• Improvement teams are common | Strong consistency of training in DMAIC; Government funding was critical to deployment; Building skills is critical; Project teams common, Coaching is strong | Strong consistency of training in DMAIC; Government funding was critical to deployment; Building skills is critical; Project teams common; Coaching is evident; training | Consistency in training; Coaching process; Building skills across the organization; Teams widespread; Boot camp type training; adult training techniques | Consistency of training under the GE processes; Funding not relevant; Improvement teams with suppliers as members common; Coaching is strong; Investment in training critical; | Consistency of training by key customer; Funding not relevant; Building skills is critical; Project teams common; Coaching is evident | Varied training providers internationally and for business units; skills being built in some business units | DMAIC with quality tools being used – a very basic statistical level but consistent; Teams are common in some parts of the hospital |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | suppliers | | certification of belts for competency; training suppliers | | | |
| 4 | • Project Focus<br>• Strategic selection of projects | Strong project focus | Strong project focus | Strong project focus<br><br>Strategic selection of projects through central coordination unit<br><br>Full commitment to projects | Strong project focus; Strategic selection of projects through internal process | Strong project focus | Project focus in some areas; | Only in some areas critical for funding opportunities |
| 5 | • Data focus<br>• KPI's clearly stated and flow down and up from Board | Moderate data use in projects; regular recording and monitoring of KPI's; Link to QMS important | Moderate data use in projects; regular recording and monitoring of KPI's | Strong focus of performance measures for all departments and projects | Strong data focus; KPI's from top to shop floor | Moderate data use in projects; strong on recording of KPI's | Strong focus of performance measures for some departments and projects | Performance measurements cascaded from leadership team to departments |

Table 4.4: Examples of critical success factors using five broad factors

| Benefits across the cases | SME Automotive Supplier | Large Supplier to Mining & Heavy Vehicle Industry | Bank | OEM Supplier International | OEM Supplier to Truck Industry (SME) | IT Service | Hospital |
|---|---|---|---|---|---|---|---|
| Financial Savings | Moderate savings from projects | Moderate savings from projects | Significant | Significant savings from projects | Moderate savings from projects | Some | Some |
| Productivity/efficiency improvement | Better throughput | Less rework | Yes | Less rework | Less rework | Yes | Yes |
| Capability Improvements | Better Conformance to specification | Better Conformance to specification | Yes | Better Conformance to specification | Better Conformance to specification | Yes | Yes |
| Lead time improvements | Ongoing reduction in lead time due to customer demands | Small reduction in lead times | Yes | Small reduction in lead times | Small reduction in lead times | Yes | Yes |
| Gaining customer awards | Not applicable | Not applicable | | Not applicable | A focus for this company | Yes | |
| Competitiveness | Enabled company to compete | Strong leader but gained market share | Yes | | Gained more business from key customer | Not applicable | Yes |
| Cultural impacts | Made a good culture great | Made a good culture great | Yes | Was a means of creating a good culture | Made a good culture great | Ongoing | Yes |
| Employee empowerment | Enhanced staff empowerment | Enhanced staff empowerment | Yes | | Enhanced staff empowerment | Not applicable | Yes |

Table 4.5: Benefits of Lean Six Sigma identified for all cases

| Challenges across the cases | SME Automotive Supplier | Large Supplier to Mining & Heavy Vehicle Industry | Bank | OEM Supplier International | OEM Supplier to Truck Industry (SME) | IT Service | Hospital |
|---|---|---|---|---|---|---|---|
| Attrition in “experts” or “belts” leaving company | Not applicable | Not applicable | Major challenge | Some movement of Belts | Not applicable | Major challenge | Not relevant |
| Sustaining improvements | Common issue | Common issue | Common issue | Common issue | Common issue | Common issue | Common issue |
| Deploying across whole business | Achieved | Moving from business unit to national deployment | In place | Achieved | Achieved | A challenge | A challenge |
| Involving suppliers and customers | Involving suppliers only | Involving suppliers | Not relevant | | Involving suppliers only | | Major challenge |
| Sustaining use of tools | Set as mandatory | Set as mandatory | Yes | Set as mandatory | Yes | Yes | OK |
| Need for standardization of tools | Common issue | Common issue | Common issue | Common issue | Common issue | Common issue | Not applicable |
| Maintain competency of Belts | Not applicable | Not applicable | Ongoing challenge | Ongoing challenge | Not applicable | Ongoing challenge | Not applicable |
| Downturn in Australian Manufacturing | Critical | Critical | Not applicable | Critical | Critical | Not applicable | Not applicable |
| Lack of awareness of continuous improvement initiatives | Not applicable | Not applicable | Minor challenge | Not applicable | Not applicable | Minor challenge | Minor challenge |
| Employee working mentality and habits | Not applicable | Exists a little | Exists but not widespread | Not applicable | Not applicable | Not Relevant | Exists but not widespread |
| Lack of strategic direction | Not relevant | In some business units | Exists but not widespread | Not relevant | Not relevant | Not Relevant | Exists but not widespread |

Table 4.6: Challenges across all cases

## 4.10 Summary of Chapter 4

Chapter 4 has presented the findings from fieldwork phase 1, which has involved face-to-face interviews using semi-structured questions in seven organizations to obtain more insights into Lean Six Sigma in Australia.

In particular, this fieldwork provides additional insights into the drivers of Lean Six Sigma, the deployment strategies, the competencies of the organizations that are necessary for a successful deployment. The benefits and challenges provide insight into the future direction of Lean Six Sigma for Australian business.

The critical success factors noted in section 4.9.4 and summarized in Table 4.2 provide additional insights into the competencies of the organization necessary for the successful deployment of Lean Six Sigma.

Using the competencies presented in Table 4.2 and those competencies derived from the literature review (presented in Table 2.5), competencies are developed for use in the model presented in Figure 3.2. These developed competencies are summarized in Table 7.2.

# 5. Chapter Five: Fieldwork phase 2 (In-depth case Analysis)

## 5.1 Introduction

During the face-to-face interviews with the participant in case 7 (the Healthcare organization) discussed in chapter 4, the opportunity arose to obtain data from all the senior hospital department managers in order to correlate the competencies of the Hospital with the performance measures used at the Hospital. The data was collected using two structured questionnaires. This was fieldwork phase 2.

Questionnaire 1 showed the competencies of the Hospital. The competencies were based on Powell (1995) in an analysis of what factors created a successful TQM deployment.

Questionnaire 2 showed the performance measures of the Hospital. The performance measures were defined by the principal participant, who was the Director of Risk and Clinical Governance. For the purposes of the study, performance measures for the Hospital were defined as "equitable and timely access into the clinical services of emergency, outpatients and surgery and the appropriate safe and timely discharge back to the community".

Questionnaires 1 and 2 are presented in appendix A2 and A3 respectively.

Seventeen Hospital department managers were identified by the Hospital's executive management team to take part in the research. The managers completed both questionnaires by ranking the items and performance measures. Initial interviews were held with the principal participant and the Director of Nursing, who were both part of the Executive management team.

The purpose of this fieldwork was to correlate the key factors of the Hospital's Lean Six Sigma program with the performance measures of the Hospital. This fieldwork provides insights, for the model described in Figure 3.2, into the relationship between program success and organizational competence. The analysis of the data obtained from the questionnaires was useful to identify what were the critical success factors (or competencies) for the deployment of DMAIC to the performance of the Hospital. The two questionnaires enabled respondents to provide responses describing the relationship between the Hospital's organizational competencies, personal competencies and performance measures.

In the remaining part of this chapter, section 5.2 describes the reliability and validity of the two questionnaires. Sections 5.3 and 5.4 summarize the results and analysis of the data collected using the questionnaires and section 5.5 discusses the results. Finally, section 5.6 provides a summary of the chapter.

## 5.2 Questionnaire Reliability and Validity

Powell (1995) uses certain items (or constructs) for each of the factors presented in questionnaire 1. For example for "Open Organization" the following scales are used - "A more open, trusting organizational culture"; "less bureaucracy"; "frequent use of cross-departmental teams"; "Use of empowered work teams". The factors presented in Powell (1995) are fairly generic and can apply to manufacturing and service organizations and to any quality program. The fact that the literature review has demonstrated some overlap between TQM and Lean Six Sigma, it is assumed that the 19 factors presented in column 2 of Table 5.1 are appropriate for Lean Six Sigma. There was agreement from the principal participant that these factors were appropriate for the Hospital.

During discussions with the Hospital's executive management team, the items representing the factors, as presented in Powell (1995) needed to be modified to conform to the specific terminology in the Hospital. The modified items were included in questionnaire 1 and the final version is presented in appendix A2.

Powell (1995) also constructs items that correspond to the performance measures of the organization. For the Hospital, 16 items were constructed in consultation with the principal participant and the Director of Nursing to measure performance. The revised measures were included in questionnaire 2 and the final version is presented in appendix A3.

Approval for the questionnaire to be completion was gained from the Hospital's CEO and the Executive. The two questionnaires were sent electronically to each of the 17 senior managers and there was a 100% response rate.

To minimize respondent bias, questionnaire 1 only showed the items and not the 19 factors so that the respondents were not able to identify the factors associated with the items they were ranking.

Data from Likert scales for items representing each factor in questionnaire 1 were measured for reliability using Cronbach alpha values (Nunnally and Peteraf, 1978). Any unreliable items were removed and a comparison was then made between the expected ranks and actual ranks to indicate which factors can be improved using a paired t-test. The low sample size may distort the reliability of the average ranks and the Cronbach alpha values. Eta Squared values are computed to indicate rankings of t-statistics to give a logical order of importance of the gap between expected and actual ranks. [Eta squared $=t^2 / [t^2+N-1]$]

Actual ranks were then correlated with the ranking for the performance measures to indicate which factors are positively correlated with performance and to provide insights into appropriate strategies for the Hospital to maximize performance.

Cronbach alphas were computed for each factor and the results are presented in Table 5.1. It makes sense to evaluate the reliability of the items using the expected ranks as this is not biased by actual outcomes in the hospital.

The alpha value for the expected ranks for factors 2, 3, 8, 12, 16 and 18 are below 0.7 and these need further examination, in particular for factor 8 and 18.

Cronbach alpha value for factors 1, 4, 5, 6, 7, 9, 10, 11, 13, 14, 15, 17 and 19 are good suggesting that the items correlate well with the factor and are reliable.

| | **Factors described in Powell (1995)** | **Cronbach alpha** | **Reliable for expected ranks** |
|---|---|---|---|
| | | **Expected** | |
| 1 | Executive Commitment | 0.8008 | Y |
| 2 | Adopting the philosophy | 0.6176 | N |
| 3 | Benchmarking | 0.6836 | N |
| 4 | Training | 0.9330 | Y |
| 5 | Closer customer relationships | 0.9388 | Y |
| 6 | Closer supplier relationships | 0.8433 | Y |
| 7 | Open organization | 0.7895 | Y |
| 8 | Employee empowerment | -0.1693 | N |
| 9 | Flexible operations | 0.7932 | Y |
| 10 | Process improvement | 0.9364 | Y |
| 11 | Measurement | 0.7982 | Y |
| 12 | Organizational structures | 0.5234 | N |
| 13 | Zero defects mentality | 0.8783 | Y |
| 14 | Teams | 0.9082 | Y |
| 15 | Planning and values | 0.9652 | Y |
| 16 | Audits | 0.4694 | N |
| 17 | Problem solving tools | 0.9759 | Y |
| 18 | Design and engineering | 0.0000 | N |
| 19 | Production | 0.9089 | Y |

Table 5.1: Cronbach alphas for expected rankings for each factor

For factor 2, there are only 2 items describing this factor so no item adjustments are made. For factor 3, the largest Cronbach alpha was achieved when all items were included, so no item adjustments are made. For factor 8, when items 3 and 5 were deleted the Cronbach alpha was 0.7544, the highest for all the 5 factorial item combinations. Item 3 – “Increased employee interaction with patients and service providers is necessary?" and item 5 – "Conducting an employee survey to establish satisfaction levels and culture could be useful?" - were therefore deleted from the analysis below. Both questions may have been confusing. The Cronbach alpha for actual ranks decreases to 0.6129. For factor 12, when item 4 was deleted, the Cronbach alpha value increases to 0.7589 hence item 4 – "External quality consultants could be used to facilitate training?" - was deleted from the analysis. This item may not have been clear to some respondents. The Cronbach alpha for actual ranks decreased slightly to 0.8120.

For factor 16, there are only two items describing this factor so no item adjustments are made. For factor 18, when item 3 – "Quality Function deployment is a useful technique" - was deleted, the Cronbach alpha increased to 0.3218 which is a slight improvement in reliability. In hindsight this question is quite generic and not specific to the hospital. Item 3 was deleted from the analysis. The Cronbach alpha for actual ranks decreased to 0.7219. This factor could be deleted altogether since it is well below 0.7 even with the deleted item.

For questionnaire 2, the Cronbach alpha value is 0.9423 indicating that the items are reliable descriptions of performance for the Hospital.

## 5.3 Descriptive Statistics

Table 5.2 describes the average ranks and standard deviations of the ranks for each factor for both expected and actual rankings with items deleted which were not reliable as per the Cronbach alpha assessment. Averages are taken over all items in the questionnaire except for those items deleted following the reliability analysis. From the data presented in table 5.2, it can be observed that factor 7 - "Open Organization" is on average the most critical factor expected by the participants for the existence of a good quality program.

On average the next most critical is factor 15 – "Planning and Values" followed by factor 4 – "Training". It is interesting to note that the actual average rankings for the factors are 3.47, 4.20 and 3.56 respectively indicating that there are gaps between what is actually occurring in the Hospital and what the participants expect or would like to happen.

| | | **Expected** | | | **Actual** | | | **Deleted Items** |
|---|---|---|---|---|---|---|---|---|
| **Factor** | **Factor description** | **N** | **Mean** | **Std. Dev.** | **N** | **Mean** | **Std. Dev.** | |
| 1 | Executive Commitment | 17 | 4.4312 | .45289 | 17 | 3.9406 | .59196 | |
| 2 | Adopting the philosophy | 17 | 4.5000 | .50000 | 17 | 4.0294 | .64881 | |
| 3 | Benchmarking | 17 | 4.0400 | .66623 | 17 | 3.3735 | .56368 | |
| 4 | Training | 17 | 4.6029 | .45120 | 17 | 3.5588 | .62830 | |
| 5 | Closer customer relationships | 17 | 4.0594 | .77487 | 17 | 3.7659 | .56245 | |
| 6 | Closer supplier relationships | 17 | 4.1229 | .42683 | 17 | 3.1012 | .75719 | |
| 7 | Open organization | 17 | 4.9118 | .26430 | 17 | 3.4706 | .81912 | |
| 8 | Employee empowerment | 17 | 4.6078 | .53014 | 16 | 3.7917 | .56928 | 3 and 5 |
| 9 | Flexible operations | 16 | 4.1231 | .64255 | 16 | 3.5431 | .65435 | |
| 10 | Process improvement | 17 | 4.4353 | .49616 | 17 | 3.5765 | .81511 | |
| 11 | Measurement | 17 | 4.3535 | .47812 | 17 | 3.9800 | .44892 | |
| 12 | Organizational structures | 16 | 4.4167 | .39441 | 16 | 3.8958 | .82299 | 4 |
| 13 | Zero defects mentality | 15 | 4.3333 | .60409 | 15 | 3.8213 | .61625 | |
| 14 | Teams | 17 | 4.0818 | .38988 | 17 | 3.6265 | .52247 | |
| 15 | Planning and values | 17 | 4.6176 | .65023 | 17 | 4.2059 | .77174 | |
| 16 | Audits | 17 | 4.3529 | .42444 | 17 | 3.9118 | .61835 | |
| 17 | Problem solving tools | 17 | 4.2547 | .52118 | 17 | 3.7647 | .91139 | |
| 18 | Design and engineering | 17 | 4.2647 | .39991 | 17 | 3.6471 | .74508 | 3 |
| 19 | Production | 16 | 3.9788 | .65044 | 16 | 3.4575 | .84319 | |

Table 5.2: Average rank across the items within a factor with deleted items noted

## 5.4 Paired Samples

The ranking given by a respondent for the expected and actual levels of items are paired samples as they are given by the same person. To determine if there is any significant difference between the samples ranks, a t-test is used. The results are presented in Table 5.3.

| | **Paired Diff.** | | | | | **t** | **df** | **Sig. (2-tailed)** |
|---|---|---|---|---|---|---|---|---|
| **Item (Construct)** | **Mean** | **Std. Dev.** | **Std. Error Mean** | **95% Confidence Interval of the Difference** | | | | |
| | | | | **Lower** | **Upper** | | | |
| 1 | .4906 | .35685 | .08655 | .3071 | .6741 | 5.668 | 16 | .000 |
| 2 | .4706 | .62426 | .15141 | .1496 | .7916 | 3.108 | 16 | .007 |
| 3 | .6665 | .63651 | .15438 | .3392 | .9937 | 4.317 | 16 | .001 |
| 4 | 1.0441 | .53206 | .12904 | .7706 | 1.3177 | 8.091 | 16 | .000 |
| 5 | .2935 | .82394 | .19983 | -.1301 | .7172 | 1.469 | 16 | .161 |
| 6 | 1.0218 | .71211 | .17271 | .6556 | 1.3879 | 5.916 | 16 | .000 |
| 7 | 1.4412 | .84562 | .20509 | 1.0064 | 1.8760 | 7.027 | 16 | .000 |
| 8 | .8333 | .58373 | .14593 | .5223 | 1.1444 | 5.710 | 15 | .000 |
| 9 | .5800 | .66154 | .16539 | .2275 | .9325 | 3.507 | 15 | .003 |
| 10 | .8588 | .83296 | .20202 | .4306 | 1.2871 | 4.251 | 16 | .001 |
| 11 | .3735 | .35251 | .08550 | .1923 | .5548 | 4.369 | 16 | .000 |
| 12 | .5208 | .58333 | .14583 | .2100 | .8317 | 3.571 | 15 | .003 |
| 13 | .5120 | .51832 | .13383 | .2250 | .7990 | 3.826 | 14 | .002 |
| 14 | .4553 | .55360 | .13427 | .1707 | .7399 | 3.391 | 16 | .004 |
| 15 | .4118 | .88803 | .21538 | -.0448 | .8683 | 1.912 | 16 | .074 |
| 16 | .4412 | .58316 | .14144 | .1413 | .7410 | 3.119 | 16 | .007 |
| 17 | .4900 | .91380 | .22163 | .0202 | .9598 | 2.211 | 16 | .042 |
| 18 | .6176 | .69663 | .16896 | .2595 | .9758 | 3.656 | 16 | .002 |
| 19 | .5213 | .68905 | .17226 | .1541 | .8884 | 3.026 | 15 | .009 |

Table 5.3: Paired samples t-test

All differences are significant at 1% except factors 5, 15 and 17 which correspond to the factors - "Closer customer relationships", "Planning and Values" and "Problem solving tools" respectively. Eta-squared levels are also used to assess a priority of the differences so that the highest value relates to the opportunity for the largest improvements. Table 5.4 gives the Eta-squared values in ascending order with factor 7 – "Open organization" - being the highest and factor 5 – "Closer customer/patient relationships" - being the lowest.

| **Factor** | **T statistic** | **Number of items** | **Eta squared** |
|---|---|---|---|
| 7 | 7.027 | 2 | 0.980 |
| 4 | 8.091 | 4 | 0.956 |
| 8 | 5.71 | 3 | 0.942 |
| 1 | 5.668 | 3 | 0.941 |
| 18 | 3.656 | 2 | 0.930 |
| 16 | 3.119 | 2 | 0.907 |
| 2 | 3.108 | 2 | 0.906 |
| 11 | 4.369 | 3 | 0.905 |
| 3 | 4.317 | 3 | 0.903 |
| 13 | 3.826 | 3 | 0.880 |
| 12 | 3.571 | 3 | 0.864 |
| 9 | 3.507 | 3 | 0.860 |
| 6 | 5.916 | 7 | 0.854 |
| 19 | 3.026 | 3 | 0.821 |
| 10 | 4.251 | 5 | 0.819 |
| 15 | 1.912 | 2 | 0.785 |
| 17 | 2.211 | 3 | 0.710 |
| 14 | 3.391 | 8 | 0.622 |
| 5 | 1.469 | 3 | 0.519 |

Table 5.4: Eta-squared ranked in descending order

Table 5.5 gives correlations between average actual ranks for factors and performance. Actual ranks are used since this represents the true data and the expected rankings are theoretical. From Table 5.5, it is noted that factors 4, 5, 10, 11, 12 and 13 are significantly positively correlated to performance at the 1% level. Factors 1, 3, 6, 7, 8, 9, 15 and 16 are not significantly correlated with performance at the 5% level. Factors 2, 17, 18 and 19 are not significantly positively correlated with performance.

| Average Actual for Factor | N | Pearson Correlation | Sig. level (2-tailed) |
|---|---|---|---|
| 1 | 17 | .457 | .065 * |
| 2 | 17 | .251 | .330 |
| 3 | 17 | .512 | .036 ** |
| 4 | 17 | .648 | .005 *** |
| 5 | 17 | .730 | .001 *** |
| 6 | 17 | .578 | .015 ** |
| 7 | 17 | .524 | .031 ** |
| 8 | 16 | .527 | .036 ** |
| 9 | 16 | .602 | .014 ** |
| 10 | 17 | .714 | .001 *** |
| 11 | 17 | .647 | .005 *** |
| 12 | 16 | .772 | .000 *** |
| 13 | 15 | .824 | .000 *** |
| 14 | 17 | .463 | .062 * |
| 15 | 17 | .499 | .041 ** |
| 16 | 17 | .493 | .044 ** |
| 17 | 17 | .330 | .196 |
| 18 | 17 | .340 | .182 |
| 19 | 16 | .427 | .099 * |

Table 5.5: Bivariate correlations between average performance and average actual rankings for each factor

*Notes - *** Correlation is significant at the 0.01 level (2-tailed); ** Correlation is significant at the 0.05 level (2-tailed); * Significant at 10%*

## 5.5 Discussion of results

There are gaps between what the respondents expect as being a necessary part of a quality program and the actual results in the Hospital. In other words, there are gaps in the competencies of the Hospital. A number of factors that comprise the quality program are significantly associated with the Hospital's performance. A summary of the results appears in Table 5.6. The analysis is limited by the size of the sample, that is, number of respondents.

Based on the Cronbach alpha values, factors and constructs presented in questionnaire 1 are a reliable measure of the Hospital's quality program and constructs presented in questionnaire 2 are a reliable measure of performance in the Hospital that is, patient access to outpatients. However, some items (constructs) for certain factors were inappropriate and were deleted during further analysis. It was commented by the Director of Risk and Clinical Governance for the Hospital that some of these items are generally more aligned to a manufacturing environment and this may give rise to the small Cronbach alpha values. Caution must be noted about the sample size of 17 when interpreting the Cronbach alpha values.

There were gaps identified between expected and actual for most factors (Table 5.2) indicating many opportunities to improve the quality program to that expected by most respondents, that is the expected competencies of the organization. Factor 7 – "Open organization" - has the highest potential for improvement. This may be related to the managers becoming more aware that they can influence change. Factor 5 – "Closer relationships with patients" - has the lowest potential for improvement as it is not significantly different from that expected by respondents. This is highly likely to be the result of hospital staff believing they put a great deal of emphasis on caring for patients and therefore there is little room for further improvement. There has been a focus on increasing managers understanding of system design, performance measures and reducing error and improving performance in service delivery areas. This is indicated in the results where factors including "Training", "Closer customer relationships", "Process improvement", "Measurement", “Organizational structures” and “Zero defects mentality” impact significantly on patient access (Table 5.5). According to the Director of Risk and Clinical Governance, the Hospital has moved from a position of quality control audits being conducted by nursing staff almost daily, to the use of key performance indicators as flags to determine what to audit.

The results show that factors including “Adopting the philosophy”, “Team activity”, “Problem solving tools”, “Design and engineering” and “Production” do not need to be focused on for performance improvements.

It is possible that the differences between expected and actual rankings could have been due to respondents not being actively involved in that part of the quality program or they simply may have misunderstood the item. For example items within factor 18 – “Design & engineering” - and factor 19 – “Production” - are manufacturing terms not normally associated by hospital staff with their work (notwithstanding that fact that the executive management team approved the items initially). The results have enabled the Executive management team to prioritize their focus on activities corresponding to Eta-squared values in order from highest to lowest (Table 5.4 ignoring non-significant t-values) for optimum impact.

Analysis of the responses from the two questionnaires enabled identification of gaps in structures and behaviors. Importantly, a critical aspect of healthcare in an acute hospital is equitable and timely access into the clinical services of emergency, outpatients and surgery and the appropriate safe and timely discharge back to the community. The questionnaires were able to provide responses showing the relationship between structures, behaviors and outcomes.

On the basis of the results, an extension of the training course was agreed on by the executive management team to be conducted throughout all levels of the hospital. This is aimed at closing the gaps indicated in the results.

The CEO and executive of the Hospital have determined that the questionnaires will be adopted and administered regularly. Furthermore, the

Hospital will use the questionnaires in benchmarking with other like hospitals in particular partners in its international benchmarking project.

The Executive noted that a number of factors showed the actual performance was close to the performance expected by the managers. This was in agreement with the prevailing view and supported by data from the performance measures. This provided motivation for staff to continue the quality systems approach using DMAIC and reinforce the use of performance measures as valuable tools to evaluate delivery of service to patients.

## 5.6 Summary of chapter 5

Fieldwork phase 2 was presented in this chapter including a description of the data collected, a verification of the two questionnaires used and a discussion of the results. It provides further insights into the competencies of an organization developed from the literature review (Table 2.5) and developed in fieldwork phase 1 (Table 4.2).

In particular, fieldwork phase 2 describes which competencies need further support by the Executive of the Hospital (Table 5.3). It also provides competencies that are significantly related to Hospital performance (Table 5.5). This provides insight into the order of importance of which competencies need to the supported first.

The results presented in Tables 5.3 and 5.5 provide further examples of appropriate organizational competencies that have been developed in the model presented in Figure 3.2 and tested in fieldwork phase 4.

# 6. Chapter Six: Fieldwork phase 3 (Open Questionnaires)

## 6.1 Introduction

In order to provide further insight into the personal competencies noted in the literature review (section 2.8), an open questionnaire was sent to two senior and experienced Master Black Belts.

Respondent 1 was selected since this person had responsibility for the deployment of Lean Six Sigma in a large Australian Bank and had the direct management of a large number of Master Black Belts and Black Belts. Respondent 1 also was one of the participants interviewees in the face-to-face interviews discussed in chapter 4. Respondent 2 was selected since this person was working as a consultant and trainer in Lean Six Sigma in Australia and has had the opportunity of facilitating a number of large scale deployments of Lean Six Sigma using many experts at Black and Master Black Belt levels.

Both respondents were asked to complete an open questionnaire that addressed the question – "What attributes/competencies do you observe in your Master Black Belts and Black Belts in your organization or organizations you have been involved with?"

A summary of the answers appears in the next two sections.

## 6.2 Master Black Belts

Respondent 1 listed the following competencies necessary for a Master Black Belts:

- Developing and contextualizing the DMAIC methodology to the organization
- Delivering Black Belt training
- Helping others to learn how to deliver Green Belt training

- Undertaking certification of Green Belts & Black Belts
- Providing of technical and statistical advice
- Reviewing of project work particularly where the use of advanced tools is involved.

Respondent 2 suggested that Master Black Belts should have a more administrative role rather than simply being active practitioners leading process improvement projects. It was suggested they should have either a) accountability for a division of the organization or b) coaching and/or support roles for a number of practicing Black Belt Project Leaders. When introducing Six Sigma deployments within organizations, respondent 2 recommends that Master Black Belts are indeed seasoned professionals. These are individuals who have completed their engagement strategy and Six Sigma training followed by three or more years of leading successful projects using a variety of the tools available to them. Additionally, Respondent 2 recommends that Master Black Belts also have identifiable leadership and management traits as defined by the organization’s own standards. These traits are due to the preposition that they will be more than leaders of multiple projects in a Master role. They would be expected to be leaders and ambassadors within the organization, coaching several Black Belts in a coordinated body of work.

These competencies indicate that a high level of understanding and experience are required to qualify as a Master Black Belt. The key competencies for a Master Black Belt, noted by these two respondents are shown in Table 6.1.

| |
|---|
| Develop implementation strategy |
| Coach project teams |
| Coach Black Belts in advanced statistics |
| Deliver training to Black Belts |
| Leadership and management traits |
| Coordinate multiple projects across the organization |
| Have a role with high influence |
| Manage certification programs |

Table 6.1: Master Black Belt competencies

## 6.3 Black Belts

Respondent 1 suggested that Black Belts in their organization were required to have a strong statistical knowledge and demonstration of competent application of advanced statistical tools and making use of the information gained to address the business problem. Respondent 1 stated that Black Belt certification also required minimum standards of leadership, project management, and coaching and benefits delivery. Black Belts are used in the team as senior coaches, often leading larger programs of work with more junior coaches managing individual project streams. They are expected to mentor Green Belts and Black Belts on the way to certification and contribute to the delivery of training.

Respondent 2 indicated that Black Belts should be full-time project leaders improving processes within their organizations. Typically the projects are significant (e.g. millions of dollars of bottom line value and/or spanning across divisional boundaries). Sometimes Respondent 2 had noticed that individuals will complete the necessary training and, for one reason or another, fail to complete projects.

By and large, most of the Black Belts Respondent 2 had worked with have indeed produced solid results (sometimes "stunning results") for their organizations by improving processes using the disciplined approach that DMAIC and its tools bring.

The most interesting factor Respondent 2 always finds when these project leaders discuss their projects is that 70% of their time is taken up with "people issues". Getting sufficient stakeholders to accept their improvements and ensuring these are sustained is their main focus. The "stats and data analysis" section of a project always seems relatively straight forward according to Respondent 2.

The key competencies for a Black Belt, noted by these two respondents are shown in Table 6.2.

| |
|---|
| Statistical skills |
| Customer focus to translate problem to process |
| Finance skills |
| Leadership skills |
| Project team skills |
| Multiple projects |
| Mentor Green belts and less experienced Black Belts |
| Full time |
| Results driven |
| Data driven |

Table 6.2: Black Belt competencies

## 6.4 Summary of chapter 6

This chapter presents the results of an open questionnaire completed by two senior and experienced Master Black Belts. This provides further insights into the personal competencies of the Lean Six Sigma project leaders (Black Belts) and the deployment facilitator (Master Black Belt) that were initially developed from the literature review in Chapter 2 (sections 2.8.4.2 and 2.8.4.3 respectively).

# 7. Chapter Seven: Fieldwork phase 4 (National Survey)

## 7.1 Introduction

In order to contribute to the theory on Lean Six Sigma relating to the sustainability of a Lean Six Sigma deployment, a model has been developed from the literature review and fieldwork phases 1, 2 and 3. This model is presented in Figure 3.2 for convenience and repeated below in Figure 7.1.

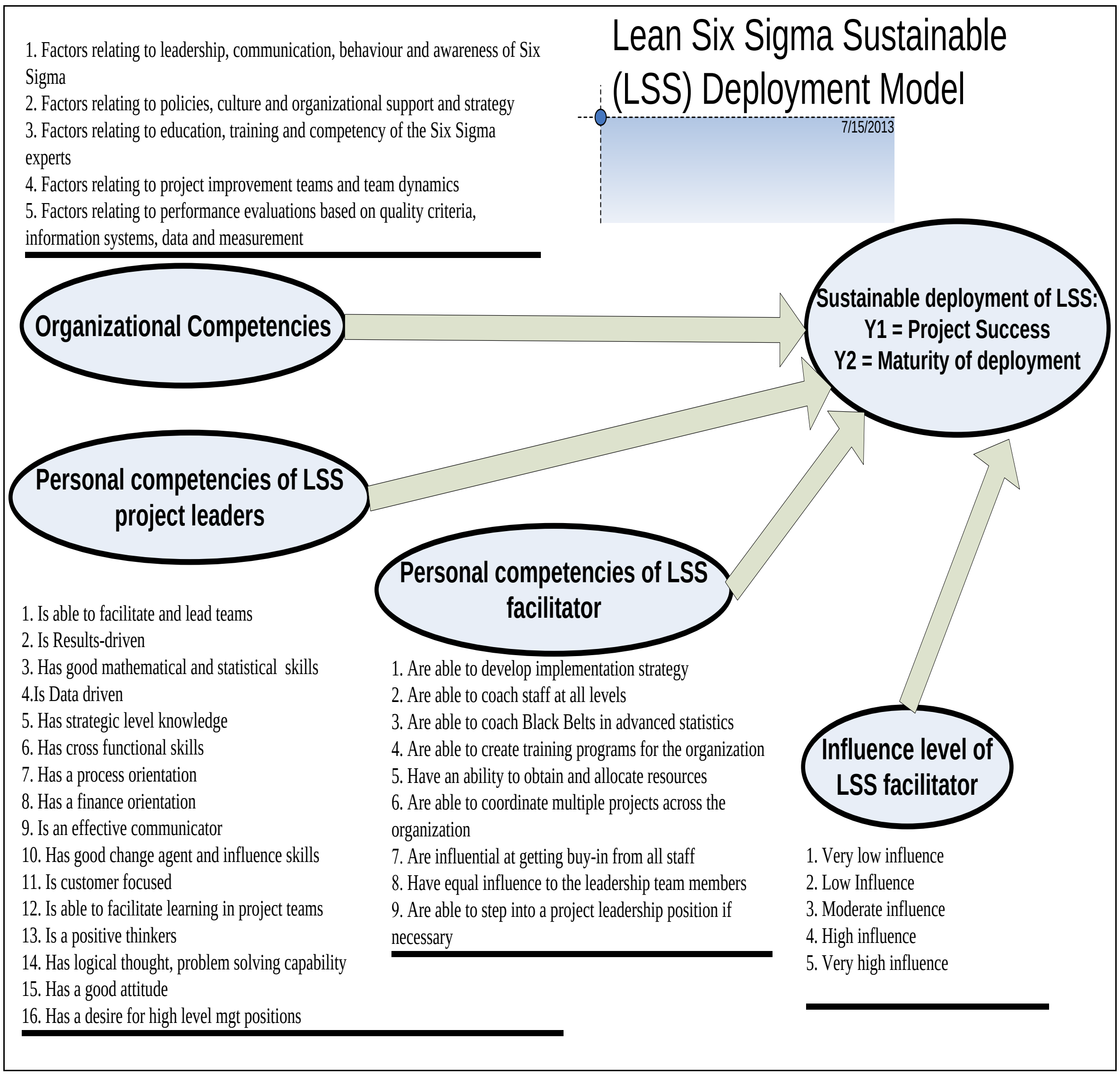


Figure 7.1: Lean Six Sigma Sustainable Deployment Model

Figure 7.1 presents a relationship between two response variables, namely program maturity and project success, and a number of explanatory variables including organizational competence, personal competence of the program facilitator (Master Black Belt), personal competence of the project leaders (Black Belts) and the level of influence of the Lean Six Sigma program facilitator.

The organizational competencies have been developed from the literature and fieldwork phases 1 and 2. The personal competencies of the program facilitator and the project leaders have been developed from the literature review and fieldwork phase 3. The personal competencies for both the program facilitator and project leader are further divided into technical and interpersonal competencies based on the literature review and fieldwork phase 3. The levels of influence of the program facilitator are based on the literature review and fieldwork phases 1 and 3.

A survey instrument was developed to objectively test the model. The survey instrument is presented in appendix A4. The survey was sent to Operations Excellence executives, or those managers with equivalent roles, that were in charge of, or facilitated, the deployment of Lean Six Sigma in many large and medium-sized organizations in Australia. The organizations were those that have been known to have deployed Lean and Six Sigma in Australia. This included manufacturing, service and the public sector.

The collection of data from this National survey in Australia and the analysis of results represents fieldwork phase 4. An evaluation of these results was made at three focus group sessions in Melbourne, Sydney and Perth. Attendees at the focus group included respondents and other experts in Lean Six Sigma.

In the remaining part of this chapter, section 7.2 describes the sample, section 7.3 explains the survey questions, section 7.4 develops the response and explanatory factor constructs, section 7.5 presents the results, section 7.6 presents the focus group comments and section 7.7 provides a general discussion of results. Finally, in section 7.8 a summary of the chapter is provided.

## 7.2 Survey Sample

In many large organizations, the program facilitator of a Lean Six Sigma deployment usually is a Master Black Belt in Lean Six Sigma and the project leaders usually are Black Belts in Lean Six Sigma. For SME's, the program facilitator might be a Quality or Process Improvement Manager and the project leaders might have other roles like Quality coordinators or Process Improvement specialists with less formal qualifications in Lean Six Sigma.

In Australia, the population of Operations Excellence practitioners and those with similar roles for organizations that are known to have deployed Lean Six Sigma has been estimated at approximately 150 based on the current membership of the Australasian Association of Lean Six Sigma practitioners (AASSP, 2010), the membership of the Association of Manufacturing Excellence (AME, 2008) and the knowledge of the researcher who works in the field of Lean Six Sigma as a trainer, coach and consultant.

Ninety-five surveys were received from the Operations Excellence executives and other senior managers representing a response rate of approximately 63.3%. All respondents were highly qualified in other disciplines to Bachelors or above and most were qualified to, at least the level of Black Belt in Lean Six Sigma.

Of the 95 respondents, 79 are based in Australia and 16 are based overseas but are involved as consultants/trainers to the Australian organizations directly, or through other consultancies based in Australia. The respondents were generally the facilitator of the Lean Six Sigma programs. In some cases the respondent was not the facilitator but commented on behalf of the facilitator. The contact details were obtained from various resources including the Australasian Association of Six Sigma Practitioners (AASSP, 2010), the Association of Manufacturing Excellence (AME, 2008) and other networks.

There are a number of smaller and medium-sized companies that only have deployed Lean and these have not been sampled since they have not deployed Six Sigma. These are not included in the estimate of 150 organizations above.

## 7.3 Survey Questions

The survey questions obtain information on the respondents and their qualifications, the organization, projects success measures, program maturity level, an assessment of the personal competencies of a typical Black Belt (that works in the organization or is known to the respondent), a self-assessment of the competencies as the deployment facilitator (or an assessment of the deployment facilitator) and an assessment of organizational competencies (that is what factors are supported by the organization).

Information on the respondents included their employment status, whether they are the deployment facilitator, the level of influence of the deployment facilitator, how long they have been working in Lean Six Sigma, how many projects they have facilitated and how many days of Lean Six Sigma training they had received. Employment status is included to identify whether the respondent is an employee or a trainer or a consultant. If a trainer or consultant completed the survey, their results may be across a number of organizations. If they were not the deployment facilitator they were asked to answer the level of influence of the deployment facilitator.

Information on the organization included the industry sector, the size of the organization measured by the number of employees and how long they have been active in Lean Six Sigma. The survey instrument is presented in appendix A4.

## 7.4 Development of factor items

### 7.4.1 Introduction

Project success and program maturity represent the responses in the model. The following variables represent the explanatory variables in the model:

1. The organizational competence measured by support of various factors
2. The technical skills level of the deployment facilitator
3. The interpersonal skills level of the deployment facilitator

4. The level of influence of the deployment facilitator
5. The technical skills of the improvement project leaders
6. The interpersonal skills of the improvement project leaders

### 7.4.2 Response factor Constructs

The following response variables were used to measure program success, namely project success and maturity of the program deployment. The selection of these response variables is based on the literature review in sections 2.6.3 and 2.6.4 respectively. Project success is measured by - Overall Quality, Process Efficiency, Responsiveness, Cost reduction and Project Schedule Adherence. The relevant section in the survey instrument is section B, question 12. Program maturity was measured by levels and descriptions as presented in Table 7.1 (Raje, 2009). The relevant section in the survey instrument is section B, question 13.

| **Program Maturity Level** | **Description** |
|---|---|
| 1 | The "Launch" is the starting point wherein an initial few visionaries in the organization launch Lean Six Sigma, training is initiated and projects begin |
| 2 | The "Early Success" is where the initial projects are yielding results and early successes are being achieved |
| 3 | The "Scale Replication" stage is where the early success has led to other parts of the organization buying into Lean Six Sigma and a broader launch of projects is underway |
| 4 | The ""Institutionalization" is where projects are yielding broad-based financial impact throughout many parts of the organization |
| 5 | "Culture Transformation" is where Lean Six Sigma is part of the organizational DNA, financial impact is sustained and the Lean Six Sigma culture is pervasive – even beyond the Lean Six Sigma practitioners and beyond the organization boundaries |

Table 7.1: Lean Six Sigma Program Maturity Levels – source (Raje, 2009)

### 7.4.3 Organizational Competencies

Based on the literature review in section 2.8.2 and fieldwork phases 1 and 2, a list of factors and constructs (items) representing competencies of the organization have been developed and are presented in Table 7.2. The relevant section in the survey listing these competencies is section E.

| Factor | Construct |
|---|---|
| **1** | **Factors relating to leadership, structure, behavior and awareness of LSS** |
| | An organization that supports Leadership |
| | An organization that supports Line Management drive |
| | An organization that supports the role of deployment facilitator |
| | An organization that supports continuous improvement |
| | An organization that supports a structured approach to Black Belt selection |
| **2** | **Factors relating to policies, culture, organizational support, communication and strategy** |
| | An organization that supports employee empowerment |
| | An organization that supports rewards and recognition |
| | An organization that supports a community spirit of improvement and emotional intelligence |
| | An organization that supports the sharing of Improvement initiatives with all stakeholders |
| | An organization that supports cross functional collaboration internally and externally |
| **3** | **Factors relating to education, training and competency of the LSS experts** |
| | An organization that supports building skills across the organization |
| | An organization that supports consistency of training in DMAIC |
| | An organization that supports ongoing training without compromise |
| | An organization that supports quality learning and knowledge gathering |
| | An organization that supports coaching and mentoring of others |
| | An organization that builds on previous initiatives e.g. TQM, BPR |
| **4** | **Factors relating to project improvement teams and project management** |
| | An organization that supports participation in a team environment and an understanding of team dynamics |
| | An organization that rewards team based improvements |
| | An organization that supports a structured approach to improvement project selection and management |
| **5** | **Factors relating to performance evaluations based on quality criteria, information systems, data and measurement** |
| | An organization that supports collecting good data and performance measures |
| | An organization that supports a zero defects mentality |
| | An environment that embeds the Lean Six Sigma program in the Quality Management system |
| | An organization that supports the focus on improvement of processes |

Table 7.2: Specific constructs used for organizational competence in the survey

### 7.4.4 Personal Competencies

The items for the personal competencies of the Black Belts have been derived from the literature review in section 2.8.4.2 and fieldwork phase 3 (Table 6.2). These competencies are presented in Table 7.3. The relevant section of the survey listing these competencies is section C.

| **Technical Constructs** | |
|---|---|
| 1 | Is able to facilitate and lead teams |
| 2 | Is Results-driven |
| 3 | Has good mathematical and statistical skills |
| 4 | Is Data driven |
| 5 | Has strategic level knowledge |
| 6 | Has cross functional skills |
| 7 | Has a process orientation |
| 8 | Has a finance orientation |
| **Interpersonal Constructs** | |
| 9 | Is an effective communicator |
| 10 | Has good change agent and influence skills |
| 11 | Is customer focused |
| 12 | Is able to facilitate learning in project teams |
| 13 | Is a positive thinkers |
| 14 | Has logical thought, problem solving capability |
| 15 | Has a good attitude |
| 16 | Has a desire for high level mgt. positions |

Table 7.3: Competencies of a Black Belt

The items for the personal competencies of the Master Black Belts have been derived from the literature review in section 2.8.4.3 and fieldwork phase 3 (Table 6.1). These competencies are presented in Tables 7.4. The relevant section of the survey listing these competencies is section D.

| Technical Constructs | |
|---|---|
| 1 | Are able to develop implementation strategy |
| 2 | Are able to coach staff at all levels |
| 3 | Are able to coach Black Belts in advanced statistics |
| 4 | Are able to create training programs for the organization |
| 5 | Has an ability of obtaining and allocating resources |
| 6 | Are able to coordinate multiple projects across the organization |
| **Interpersonal Constructs** | |
| 7 | Are influential at getting buy-in from all staff |
| 8 | Have equal influence to the leadership team members |
| 9 | Is able to step into a project leadership position if necessary |

Table 7.4: Additional competencies of a Master Black Belt

### 7.4.5 Levels of influence of program facilitator

The level of influence for the deployment facilitator or Master Black Belt has also been developed from the literature review in section 2.8.4.4. This explanatory variable, known as "Influence level" of the LSS facilitator, had values 1 to 5 where 1 = very low influence and 5 = very high influence. Examples from fieldwork phases 1 and 3 are provided in Table 7.5 and are consistent with the concept in which Quality Managers need to be influential in order to ensure company-wide compliance and support of quality. The relevant section of the survey is Question 5.

| | Levels | Examples |
|---|---|---|
| 5 | Very high influence | Senior position on leadership team |
| 4 | High Influence | Improvement management responsibility across the organization |
| 3 | Moderate Influence | Business Unit responsibility/Middle management position |
| 2 | Low Influence | Department position |
| 1 | Very low influence | Analytical role |

Table 7.5: Examples of Influence levels for Master Black Belts

## 7.5 Results of the National survey

### 7.5.1 Introduction

In this section, the demographics of the sample is described, the survey instrument is checked for validity and reliability, the type of Lean Six Sigma model is presented, respondent competencies are analyzed, project leader competencies are analyzed, organizational competencies are analyzed and the sustainability model is explored. It should be noted that Figures 7.2 to 7.20 referred in the following sub-sections appear on pages 182 to 200 respectively.

### 7.5.2 Demographics of the sample

Slightly over 76% of the respondents were fully employed with the organization in the sample. The remainder were trainers or consultants engaged as contractors staff at the level of Master Black Belt.

A majority of the organizations represented in the sample were from manufacturing (35.79%) and the Finance/Insurance (13.68%) sectors. Other sectors comprised Government (7.37%), Health & Community Services (4.21%) and Mining Services (7.37%) with the balance ranging in many industry sectors.

The size of the organizations represented ranged from: – less than 51; 51 to 250; 251 to 500; 501 to 1000 and great than 1000. About 12% of the organizations have less than 51 employees, about 7% of the organizations have between 51 and 250 employees, about 7% of the organizations had between 251 and 500 employees, about 7% of the organizations had between 501 and 1000 employees and about 57% of the organizations had greater than 1000 employees.

On average, organizations across the sample are only committing 21% of their workforce of Black Belts to working at least 50% of their time on projects. The most common role of a Black Belt is a project leader with the next most common being a Coach. Half of the organizations in the sample have been active in Lean Six Sigma for an average of 7 years. The distribution is skewed to the right with some organizations being active for quite a few years. Manufacturing organizations have been active the longest at 9.2 years, followed by Health at 7.0 years, followed by Mining Services at 6.7 years, followed by Finance/Insurance at 6.1 years and then Government at 2.1 years.

### 7.5.3 Validity and Reliability of the survey instrument

As a measure of internal consistency, calculated Cronbach alpha values were calculated (Nunnally and Peteraf, 1978) for each of the categories presented in Table 7.6. As the Cronbach alpha is higher than the benchmark, then evidence exists that the items measure the same construct.

| **Category** | **Cronbach Alpha** | **Cronbach Alpha Deleting Items** |
|---|---|---|
| Black belt Technical Competencies | 0.867 | 0.857 |
| Black belt Interpersonal Competencies | 0.854 | 0.822 |
| Master Black belt Technical competencies | 0.775 | 0.732 |
| Master Black belt Interpersonal competencies | 0.694 | |
| Factors relating to leadership, structure, behavior and awareness of Lean Six Sigma | 0.805 | 0.783 |
| Factors relating to policies, culture, organizational support and strategy | 0.882 | |
| Factors relating to education, training and competency of the Lean Six Sigma experts | 0.839 | |
| Factors relating to project improvement teams and project management | 0.769 | |
| Factors relating to performance evaluations based on quality criteria, information systems, data and measurement | 0.766 | |

Table 7.6: Cronbach Alpha values

Based on these Cronbach alpha values, it makes sense to average the variables for each category. The Cronbach Alpha is only marginally not acceptable for the Master Black Belt interpersonal competencies since it is less than 0.7 (Nunnally and Peteraf, 1978). A confirmatory factor analysis was also performed for each of the scales except for the factors relating to project improvement teams and project management, since there are only three items in that scale. The key results are given below:

- For Black Belt technical competencies, the one-factor congeneric factor model fitted poorly ($\chi^2_{20}$=59.074, p<.001). Dropping item 5 (has strategic level knowledge) led to an improved fit ($\chi^2_{14}$=21.311,p=.094)
- For Black Belt interpersonal competencies, the one-factor congeneric model fitted poorly ($\chi^2_{20}$=52.842, p<.001). Dropping item 10 (has good change agent and influence skills) led to an improved fit ($\chi^2_{14}$=21.235,p=.096)
- For Master Black technical competencies, the one-factor congeneric model fitted poorly ($\chi^2_{9}$=20.175, p<.017). Dropping item 4 (able to create training programs for the organization) led to an improved fit ($\chi^2_{5}$=6.479,p=.262)
- For Factors relating to leadership, structure, behavior and awareness of Lean Six Sigma, the one-factor congeneric model fitted poorly ($\chi^2_{5}$=12.920,p<.024). Dropping item 2 (supports line management drive) led to an improved fit ($\chi^2_{2}$=1.326, p=0.515?). Alternatively, item 1 or 3 could have been deleted but examination of the Cronbach alphas demonstrated that item 2 was most appropriate, although it should be noted that "line management drive" logically is part of leadership
- For Factors relating to policies, culture, organizational support and strategy, the lack of fit for the one-factor congeneric model was not significant ($\chi^2_{5}$=10.837, p<.055).
- For Factors relating to education, training and competency of the Six Sigma experts, the lack of fit for the one-factor congeneric model was not significant ($\chi^2_{9}$=14.602, p<.102).
- For Factors relating to performance evaluations based on quality criteria, information systems, data and measurement, the lack of fit for

the one-factor congeneric model was not significant ($\chi^2_2$=2.356, p<.309).

Subsequent analysis using Cronbach Alpha values was conducted on the scales, dropping the items indicated above (refer Table 7.6).

### 7.5.4 Type of Lean Six Sigma Model Deployed

The type of model deployed varies from the use of simple statistical tools, Lean and quality tools and advanced statistical tools. The most common model deployed uses the "DMAIC Simple Tools" methodology which involves simpler lean, statistical and quality tools. This corresponds to the Lean Six Sigma (Light) model of Mader (2008), who also defines a Lean Six Sigma (plus) model, Traditional Lean and Traditional Six Sigma respectively.

The next most common is Lean and Quality Tools represented as Traditional Lean (TL) model. The next most common is based on TQM and BPR. Interestingly, these organizations deploying Traditional Lean and TQM/BPR have been known to have deployed Six Sigma in the past.

Some organizations apply a hybrid of all models (mixed) within their continuous improvement programs. Refer to Figure 7.2, page 182.

In particular, the type of deployment models varies across organizational sizes and industry sectors. In manufacturing, more advanced statistical tools are used frequently. In smaller organizations, Lean and/or simple statistics are used more often.

At the end of the survey a number of respondents commented on the deployment strategies of their organizations. Direct quotes from the respondents follow:

- *Lean Six Sigma is still very top-down*
- *A Lean Six Sigma deployment can be project based and in others it is about the delivery of operations excellence foundations to all levels of organization, with particular focus on "first touch" staff*

- *Many of the deployments of Lean Six Sigma vary in structure*
- *Most use simple tools for most projects within DMAIC starting with Lean first then Six Sigma*
- *Lean is becoming more popular in focus because of its simplicity but is not easily implemented into a data-poor environment, like service*
- *Many of the projects and analysis are over simplified for organizations heavily involved with scientific rigor and experimental design where processes are the tools used to obtain product enhancement*
- *Application of Lean Six Sigma in large organizations is different than in an SME mainly due to the availability of resources.*

### 7.5.5 Respondent (Master Black Belt) Competencies

The level of influence of the facilitator was high scoring an average of 3.8 out of 5. Figure 7.3, page 183 presents the distribution of the results for "Level of Influence" of the Deployment facilitator.

An analysis of their competencies is presented in Figure 7.4, page 184. The scales -2, -1, 0, 1, and 2 are numerical equivalents to the scales described in the survey and represent totally disagree, disagree, neutral, agree and totally agree respectively. Confidence intervals are also presented in Figure 7.4, page 184 and where the lower bound of the interval is at least 1 then the average level of the competency is at least "agree".

Using a t-test to test the hypothesis that the average competency level is at least 1, the following technical and interpersonal competencies are significant at the 5% level.

Technical competencies that are at least agreed to by the respondents include:

- Are able to coach staff at all levels
- Are able to develop implementation strategy
- Are able to co-ordinate multiple projects across the organization
- Are able to create training programs for the organization.

Inter-personal competencies that are at least agreed to by the respondents include:

- Is able to step into a project leadership position, if necessary
- Are influential at getting buy-in from all staff.

Technical competencies that are not agreed to by the respondents include:

- Has an ability of obtaining and allocating resource
- Are able to coach Black Belts in advanced statistics.

Inter-personal competencies that are not agreed to by the respondents include:

- Have equal influence to the leadership team members.

Supporting these competencies, the following should be noted. Many of the qualifications of the respondents were relatively high at Master's level and above (52.6%). Most had a Bachelor's degree or above (92.6%). Most had at least a Black Belt in Lean Six Sigma (68.4%). Not all respondents were the deployment facilitator. The respondents that were not the facilitator made comment about their knowledge of the facilitator. Thirty-one respondents were the facilitator for only part of the organization. The median working time in Lean Six Sigma of the respondent is 10 years with the 25% quartile at 5 years and the 75% quartile at 14.3 years (only 90 out of 95 completed this question). The median training time in Lean Six Sigma was 30 days (only 84 out of 95 completed this question). Respondents have facilitated, on average, 83 projects with a median level of 22 projects. The distribution is highly skewed to the right indicating that a number of respondents have facilitated many projects. The maximum was 600 projects.

There is no differences between average competencies between industry sectors but there is an effect of the respondent's experience (number of years working in Lean Six Sigma) ($R^2$ = 15.5%, p = 0.0000). There is no effect of training days on the average competency level.

### 7.5.6 Project Leader (Black Belt) Competencies

Project leaders have the competencies presented in Figure 7.5, page 185. These have been assessed by the respondents as typical of a Black Belt. The scales -2, -1, 0, 1, and 2 are numerical equivalents to the scales described in the survey and represent totally disagree, disagree, neutral, agree and totally agree respectively. Confidence intervals are also presented in Figure 7.5, page 185 and where the lower bound of the interval is at least 1 then the average level of the competency is at least "agree".

Using a t-test to test the hypothesis that the average competency level is at least 1, the following technical and interpersonal competencies are significant at the 5% level.

Technical competencies that are at least agreed to by the respondents include:

- Is able to facilitate and lead teams
- Is results-driven
- Has a process orientation
- Is data-driven

Inter-personal competencies that are at least agreed to by the respondents include:

- Has logical thought and problem-solving capability
- Is customer-focused
- Is an effective communicator
- Is a positive thinker
- Has a desire for high level management positions
- Has good change agent and influencing skills

Technical competencies that are not significant include:

- Has cross functional skills
- Has good mathematical and statistical skills
- Has strategic level knowledge

- Has finance orientation

Inter-personal competencies that are not significant include:

- Is able to facilitate learning in project teams
- Has a good attitude

Average Black Belt competencies are not shown to be different by the respondents working in different industry sectors. Refer Table 7.7.

| Sector | Average Black Belt Competency |
|---|---|
| Finance/Insurance | 1.077 |
| Government | 1.196 |
| Health & Community Service | 1.156 |
| Manufacturing | 0.904 |
| Mining Services | 1.116 |
| Other | 1.004 |

Table 7.7: Average Black Belt Competencies across industry sectors

### 7.5.7 Organizational Competencies

Organizations have the following competencies presented in Figure 7.6, page 186. The scales -2, -1, 0, 1, and 2 are numerical equivalents to the scales described in the survey and represent totally disagree, disagree, neutral, agree and totally agree respectively. Confidence intervals are also presented in Figure 7.6, page 186 and where the lower bound of the interval is at least 1 then the average level of the competency is at least “agree”. Using a t-test to test the hypothesis that the support for the competency is at least 1, the following are supported by the organization and are significant at the levels shown:

- Leadership (at 5% level)
- Continuous improvement (at 5% level)
- Line management drive (at 10% level)

All other organizational competencies are not supported well by the organizations in the sample where the lower bound is to the left of “at least agree”. The six lowest are:

- Structured approach to Black belt selection
- Building on previous initiatives like TQM, BPR
- Ongoing training without compromise
- Rewards for team based improvements
- Embedding the program in the Quality Management System
- Zero defects mentality

A number of other success factors were noted by respondents in the National survey. Generally, these comments provided support that the broad category of factors (Table 2.3) was valid.

For each broad factor, it is worth noting some of these comments below as they expand the detail of the competencies developed in Table 7.2.

The points made are direct quotes from the survey.

For Leadership related factors (Factor 1, Table 2.3), the comments included:

- *Sustained support of the CEO and buy-in from leadership to invest the necessary intellectual power and strategy to really gain some benefits down the line is important*
- *Leaders must instill a culture of a “can do” attitude*
- *There must be a high level of consistent and visible sponsorship*
- *It is important to focus on the human aspects of a business improvement program*
- *Leaders must understand that strategy is how well the organization as a whole knows the customer*
- *How well are organizational processes aligned in order to deliver this desired customer experience is critical*
- *Goals must be aligned and be constantly adding value - without these two, advocacy will quickly be lost by key stakeholders/sponsors and talent will evaporate*

- *Pressures on the CEO/COO and a revolving/short cycled senior management will destroy many deployments*
- *A poorly organized business improvement strategy is a prescription for sub-optimizing results and a rapid loss of organizational interest.*

For Culture related factors (Factor 2, Table 2.3), the comments included:

- *The organization as a whole needs to be totally committed to improvement in process outcomes that influenced customer experience*
- *Continuous improvement must be an embedded mindset in an organization's DNA - this is not just about training staff and rewarding them in the short-term but to stay the course until such time as it becomes part of the organization's language*
- *It is important to ensure there is no signs of a culture of internal competition, that is a need for quick wins rather than logical thought process and that operations management (where sigma and lean play a part) threaten long held political ways of achieving senior management*
- *Focus on removing or reducing the things that frequently annoy coal-face team members*
- *Cultural engagement is key - different motivators could be used for employees (encouragement, listening, empowerment and support to make change in their areas and to work cross functional to make improvements).*

For Training Related factors (Factor 3, Table 2.3), the comments included:

- *The development of leadership as a skill across the entire organization is important as is good mentoring of team leaders and business leaders*
- *Senior management needs to be shown the demonstrated business returns from improvements initiated*
- *The organization needs to understand the Lean Six Sigma process and more importantly the project ownership and not be reliant of the Black Belt or Master Black Belt to drive the results*

- *Leaders need to understand how DMAIC fits into the strategic-operational continuum, how it should be deployed, and most importantly monitored and lead by the people in power*
- *Developing capability within the organization to run projects in line with the clearly articulated strategy of how improvement will fit within the strategic tool-set is important*
- *There is a need to understanding that organizational improvement is in essence a change management methodology with a bias towards improvement*
- *Activity based training - that is to say, each trainee should be assigned a project prior to training and then apply the tools immediately to their project as they are learned (DMAIC) is important*
- *Training how groups and people function in organizations - being able to communicate effectively, lead and inspire teams, deal with all the (often dirty) politics is important*
- *The choice of candidates for training is important including Champions (also called Stakeholders, Sponsors and so on).*

For Project related factors (Factor 4, Table 2.3), the comments included:

- *Operations Excellence project selection should be linked to overall business objectives & prioritized*
- *Projects must drive the improvements through the business planning process and there needs to be adequate resources for teams*
- *Effective communication with teams, sponsors, stakeholders and champion is important*
- *There must be the right level of modeling of the effect of variation across the end-to-end process (to a point where the customer pays for something) to ensure that the benefits will translate to the bottom line*
- *Numerous small successes will build engagement and team competencies better than fewer larger scale projects.*

It is useful to note how some respondents classified the success of projects. Some success measures, overlap with the ones specified in the survey and so this may present a limitation of the data in that the specified ones were not clear enough to some respondents. Each comment represents one count otherwise the number is noted. Some of these measures needed further explanatory but were not followed up by the researcher. A total of 17 out of 95 included additional project measures of success noted below.

- Cultural change (3 respondents)
- Lean waste reduction
- Sustainability (3 respondents)
- Resources committed
- Long-term gains
- Employee engagement (2 respondents)
- Six Sigma process compliance
- Team building
- Delivery-in-Full and On-Time
- Return on Investment
- Safety.

For data and measurement related factors (Factor 5, Table 2.3), the comments included:

- *It is important to ensure an understanding the critical core business metrics and drivers, deployment requirements and demand that data backs up a strong opinion.*

### 7.5.8 Sustainability of a Lean Six Sigma Deployment

#### 7.5.8.1 Introduction

In section 7.5.8.2 the relationship between the response variables, namely program maturity and project success and various explanatory variables is explored.

In section 7.5.8.3, an analysis of results using non-parametric tests are summarised.

In section 7.5.8.4 extracts of comments from the respondents at the end of the survey regarding maturity of a Lean Six Sigma deployment are summarised.

#### 7.5.8.2 Relationship between Responses and Explanatory Variables

Program maturity has a mean of 2.9 using a scale described in Table 7.1. This is slightly under the level of the "Scale Replication" stage (maturity = 3) where the early success has led to other parts of the organization buying into Lean Six Sigma and a broader launch of projects is underway.

Project success has an average of 3.5 on a scale of 1 to 5, averaged across all success categories including - Overall Quality, Process efficiency, Responsiveness, Cost Reduction and Project Schedule Adherence. It should be noted that even though the average project success across these success categories is significant ($F = 9.591$, $p=0.000$), for this analysis project success is pooled across these categories. This makes practical sense since the respondents did not favour any category over another except other categories were added (see section 7.5.7).

Program Maturity level is significantly different across industry sectors ($F = 2.24$, $p = 0.058$). For Government (public sector) organizations, Program Maturity level is lower and is associated with organizations that have had less time being active in Lean Six Sigma. Refer to Figure 7.7, page 187. Average Project Success is not significantly different across industry sectors ($F = 0.28$, $p = 0.923$). Refer to Figure 7.8, page 188.

Program Maturity level is not significantly different across organizational size ($F = 1.18$, $p = 0.326$). For organizations of sizes greater than 1000, the maturity level is higher than that for other organization sizes. Refer to Figure 7.9, page 189. Average Project Success is not significantly different across all organizational sizes ($F = 0.75$, $p = 0.559$). Refer to Figure 7.10, page 190.

The Program Maturity level is significantly and positively related to the number of years that an organization has been active in the program ($R^2$ = 27.9%; p = 0.000). Refer to Figure 7.11, page 191. The regression equation is:

Maturity of LSS Deployment = 2.16 + 0.112 Org active in LSS (Years)

This equation seems to imply there is a basic level of maturity in most companies in terms of continuous improvement and that this maturity increases as the deployment of a LSS program becomes more active. The $R^2$ of 27.9% suggests there are other factors influencing Program Maturity. Average Project Success does not change significantly as an organization becomes more active in LSS ($R^2$ = 2.3%, p = 0.174). Refer to Figure 7.12, page 192.

Program Maturity level and Years active is still positive and increasing when organization sector and organization size is considered. Refer to Figure 7.13, page 193 and Figure 7.14, page 194 respectively. Average Project Success and Years active varies across sectors and organizational sizes when organization sector and organizational size is considered. Refer to Figure 7.15, page 195 and Figure 7.16, page 196 respectively.

Program Maturity is positively impacted by average Black Belt competence ($R^2$ = 4.5%, p = 0.050). Refer Figure 7.17, page 197. Sub-dividing these competencies into Technical and interpersonal competencies there is no further effect. However, sub-dividing these competencies into the sixteen individual competencies shows that the competency "Is an effective communicator" is significant ($R^2$ = 21.0%; p = 0.057). So, of the sixteen competencies measured for Black Belts only one impacts on Program Maturity level and this one is significant at a level of "Agree" or above from the survey results.

Project Success is positively impacted by average Black Belt competence ($R^2$ = 15.0%, p = 0.0). Refer Figure 7.17, page 197. Sub-dividing these competencies into Technical and interpersonal competencies there is an effect of interpersonal Competence ($R^2$ = 16.4%, p = 0.088). However, sub-dividing these competencies in the sixteen individual competencies shows that "Has a good attitude" is significant ($R^2$ = 38.1%; p = 0.002) and "Has a process orientation" is significant ($R^2$ = 38.1%; p = 0.061). So, of the sixteen competencies measured for Black Belts two competencies impact on average Project Success and only "has a process orientation" is significant at a level of "Agree" or above from the survey results.

Average Master Black Belt competence does not impact the Program Maturity level but has a significant positive impact on average Project Success ($R^2$ = 15.5%, p = 0.0). Refer Figure 7.18, page 198. Dividing Master Black Belt competencies into technical and interpersonal competencies does not explain this further. However, multiple regression of Program Maturity level versus all the Master Black Belt competencies shows that "Are able to coach Black Belts in advanced statistics" is significant ($R^2$ = 13.7%; p = 0.057). So, of the nine competencies measured for MBBs only one impacts on LSS Program Maturity but this one is not significant at a level of "Agree" or above from the survey results. Multiple regression of average Project Success versus all the Master Black Belt competencies shows that none are significant.

Program Maturity level increases slightly with the influence level of the deployment facilitator but it is not significant ($R^2$ = 2.7%, p = 0.131). Average Project Success is significantly related to the level of influence of the program facilitator ($R^2$ = 6%, p = 0.03).

Average organizational competence significantly impacts the Program Maturity level ($R^2$ = 11.1%, p = 0.002). Refer Figure 7.19, page 199. Sub-dividing these competencies in the twenty-three individual competencies shows that three competencies - "An organization that supports the sharing of Improvement initiatives with all stakeholders", "An organization that supports building skills across the organization" and "An organization that supports consistency of training in DMAIC" are significant ($R^2$ = 41.4%; p = 0.05, 0.052, 0.004). So, of the twenty-three competencies measured for Organizational Competence three impact on Program Maturity level but all three are not significant at a level of "Agree" or above from the survey results.

Average organizational competence significantly impacts average Project Success ($R^2$ = 21.0%, p = 0.00). Refer Figure 7.19, page 198. Sub-dividing these competencies in the twenty-three individual competencies shows that three competencies - "An organization that supports continuous improvement", "An organization that supports a community spirit of improvement and emotional intelligence" and "An organization that supports cross functional collaboration internally and externally" are significant ($R^2$ = 44.7%; p = 0.029, 0.004, 0.038). So, of the twenty-three competencies measured for Organizational Competence three impact on average Project Success but all three are not significant at a level of "Agree" or above from the survey results.

An ordinal logistic regression model - see for example, (Venables and Ripley, 1996) - was fitted, relating Program Maturity level to organisational competence. The final model fitted was

$$\log\left[\frac{\Pr(Y \leq k)}{\Pr(Y > k)}\right] = \gamma_k - 0.819(\text{Organisational Competence})$$

with $\gamma_1 = -1.59;\ \gamma_2 = -0.04; \gamma_3 = 1.99;\ \gamma_4 = 3.08; and\ \gamma_5 = \infty$ and where $k = 1$ corresponds to "Launch"; $k = 2$ corresponds to "Early Success"; $k = 3$ corresponds to "Scale Replication"; $k = 4$ corresponds to "Institutionalisation"; and $k = 5$ corresponds to "Culture Transformation".

The regression coefficient for Organisational Competence had a t-value of 3.600. Refer Figure 7.20, page 200. If organizational competence averages disagree (that is x axis at -1), then the probability of a Lean Six Sigma launch (phase 1 of Program Maturity) is 0.7. If organizational competence averages agree (that is x axis at +1) then the probability of a Lean Six Sigma being institutionalised is 0.9.

Multiple Regression shows that the Program Maturity level versus average organizational competence, average Black Belt competence, average Master Black Belt competence and influence level is significant ($R^2$ is 13.0%, p = 0.024). Average organizational competence is the only one significant (p =

0.017). Multiple regression shows that average Project Success versus the same explanatory variables is also significant ($R^2$ = 26.0%; p = 0.00). Average organizational competence is very significant (p = 0.009).

Program Maturity level is positively and significantly related to average Project Success ($R^2$ = 7.0%, p = 0.016).

#### 7.5.8.3 Non-Parametric Tests using Mann Whitney Tests

In the regression analysis in the previous section, the $R^2$ is not high in many cases, even though the p-values are less than 0.05, suggesting that there is an influence of other variables. As such, caution must be exercised when interpreting the scatter diagrams. However, if the data for a particular explanatory variable is divided into two groups above and below a mid-point, it is possible to perform a Mann Whitney non-parametric test of medians for the low and high groups.

For the number of years active, the median Program Maturity for the group above 8 years active in Lean Six Sigma is 3.25 and the median for the group below 8 years is 2. The difference is significant (p = 0.0000). The median Project Success level for the group above 8 years is 3.6 and the median for the group below 8 years is 3.4. The difference is not significant (p = 0.3201). This confirms that project success does not improve but the Program Maturity level does improve as the number of years an organization is active is higher. That is, organizations focus on projects quickly and become more mature as they develop a culture of continuous improvement.

For the average organizational competencies, the median Program Maturity level for the group above a level of 0.7 is 3 and the median for the group below 0.7 is 2. The difference is significant (p = 0.0001). The median project success level for the group above a level of 0.7 is 3.75 and the median for the group below 0.7 is 3.2. The difference is significant (p = 0.0000). Program Maturity and project success are impacted by organizational competencies.

For the average Master Black Belt competencies, the median Program Maturity level for the group above 1.07 is 3 and the median for the group below 1.07 is 3. The difference is not significant ($p = 0.1180$). The median project success level for the group above 1.07 is 3.6 and the median for the group below 1.07 is 3.2. The difference is significant ($p = 0.0002$). Master Black Belt competence appears to have an effect on project success and not Program maturity level.

For the average Black Belt competencies, the median Program Maturity level for the group above 1.01 is 3 and the median for the group below 1.01 is 3. The difference is marginally significant at 5% ($p = 0.0499$). The median project success level for the group above 1.01 is 3.6 and the median for the group below 1.01 is 3.2. The difference is significant ($p = 0.0001$). Black Belt competence appears to have an effect on project success and not Program maturity level.

For the Master Black Belt influence level, the median Program Maturity level for the group above 4 is 3 and the median for the group below 4 is 3. The difference is not significant ($p = 0.3944$). The median project success level for the group above 4 is 3.6 and the median for the group below 4 is 3.3. The difference is not significant at 5% ($p = 0.0543$). This suggests that the influence level does not play a direct part in project success or Program Maturity. However, the level of influence is high in the sample since it is 3.8 out of 5 suggesting that full control of the program deployment Master Black Belts is important.

#### 7.5.8.4 Qualitative comments from respondents on Maturity

In the National survey, a number of general comments were made by the respondents about the maturity of a Lean Six Sigma deployment at the end of the survey. They included the following. Each bullet point is an extract of one respondent’s comments.

- *Many Lean Six Sigma deployments are in their early stages of maturity since there is a lack of experience to take on a full Six Sigma* *implementation and support it well. Many LSS experts have left the business. There is lack of leadership. There is no recognition of the LSS skills. The burden of training and convincing very high potential individuals of the merits of business improvement can be taxing. Some get bitter and cynical since results are not evident*

- *Maturity of the LSS program varies across industry sectors, but manufacturing organizations are more mature. The service sector is less mature as there is poor process definition, therefore poor process standardization and non-existent process monitoring (process control). Larger and more strategic improvements are not gaining the traction due to an absence of clear customer focus and strategic deployment*
- *Deployment strategies have been influenced by the US parent, making it difficult to build a long-term strategy within the business that would allow Lean Six Sigma to become part of the organization's DNA*
- *This company is still in early stages of deployment but engagement is building strongly at Executive level and is now embedded in the organizational blueprint. Engagement and awareness diminishes towards operational roles and this is the new focus*
- *Lean Six Sigma continues to evolve and is now becoming an essential toolkit for young engineers and a basic continuous improvement framework. Unfortunately, HR policies are not as advanced toward an empowerment that would truly enable a Lean culture*
- *It is difficult to find an organization which is getting it (Program Deployment) right in its early stages*
- *As confidence in the DMAIC methodology grows it will improve - however outside factors not supporting true continuous improvement will then blame Lean Six Sigma for any less than desired results*
- *In some fast paced environments, it can be very difficult for business leaders to remain focused on the improvement projects and it can also be difficult to mentor, monitor and implement process change*
- *The organization needs to understand the Lean Six Sigma process and more importantly owning projects and not be reliant of the Black Belt or Master Black Belt to drive the results.*

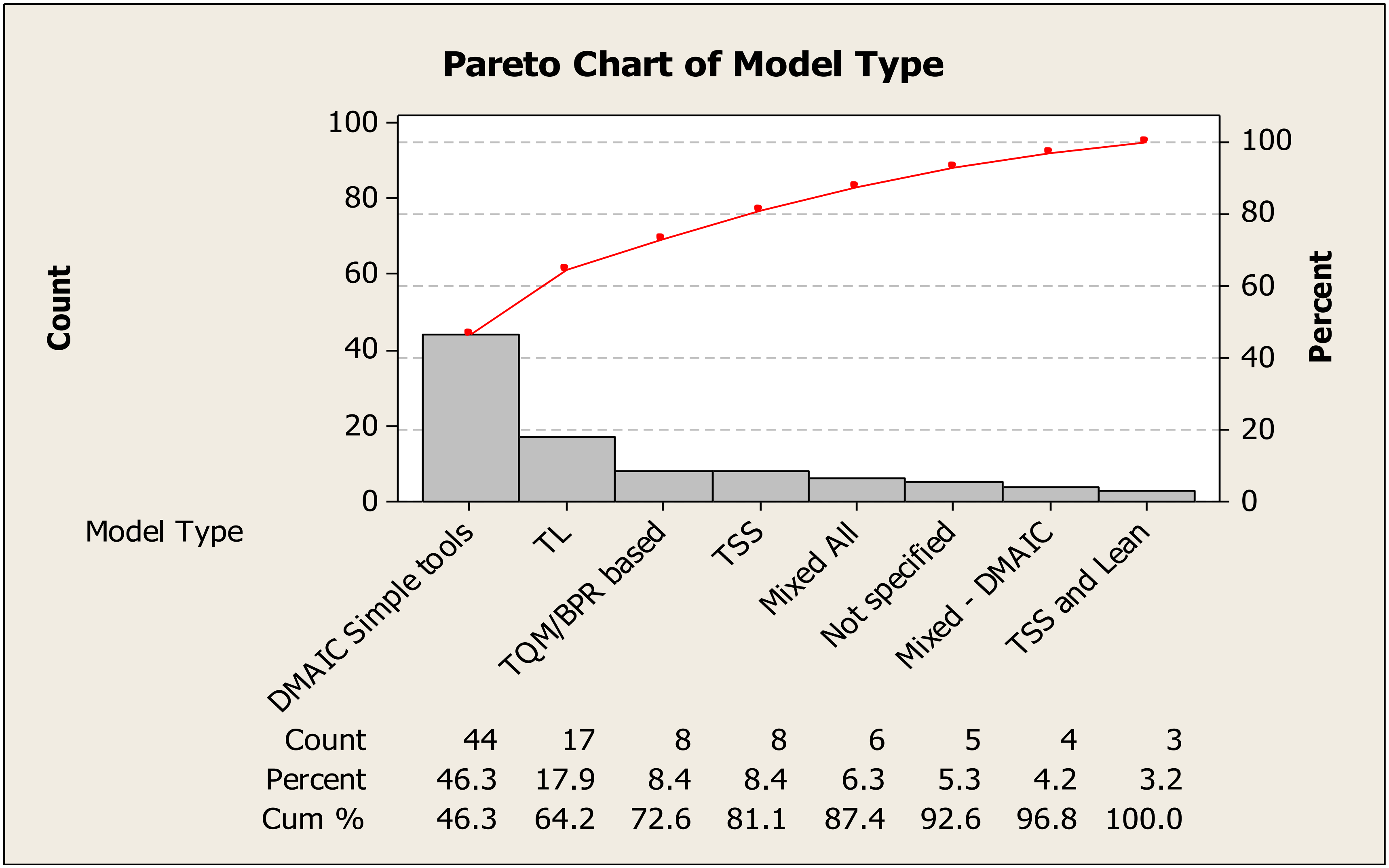


Figure 7.2: Type of Lean Six Sigma Model Deployed (n = 95)

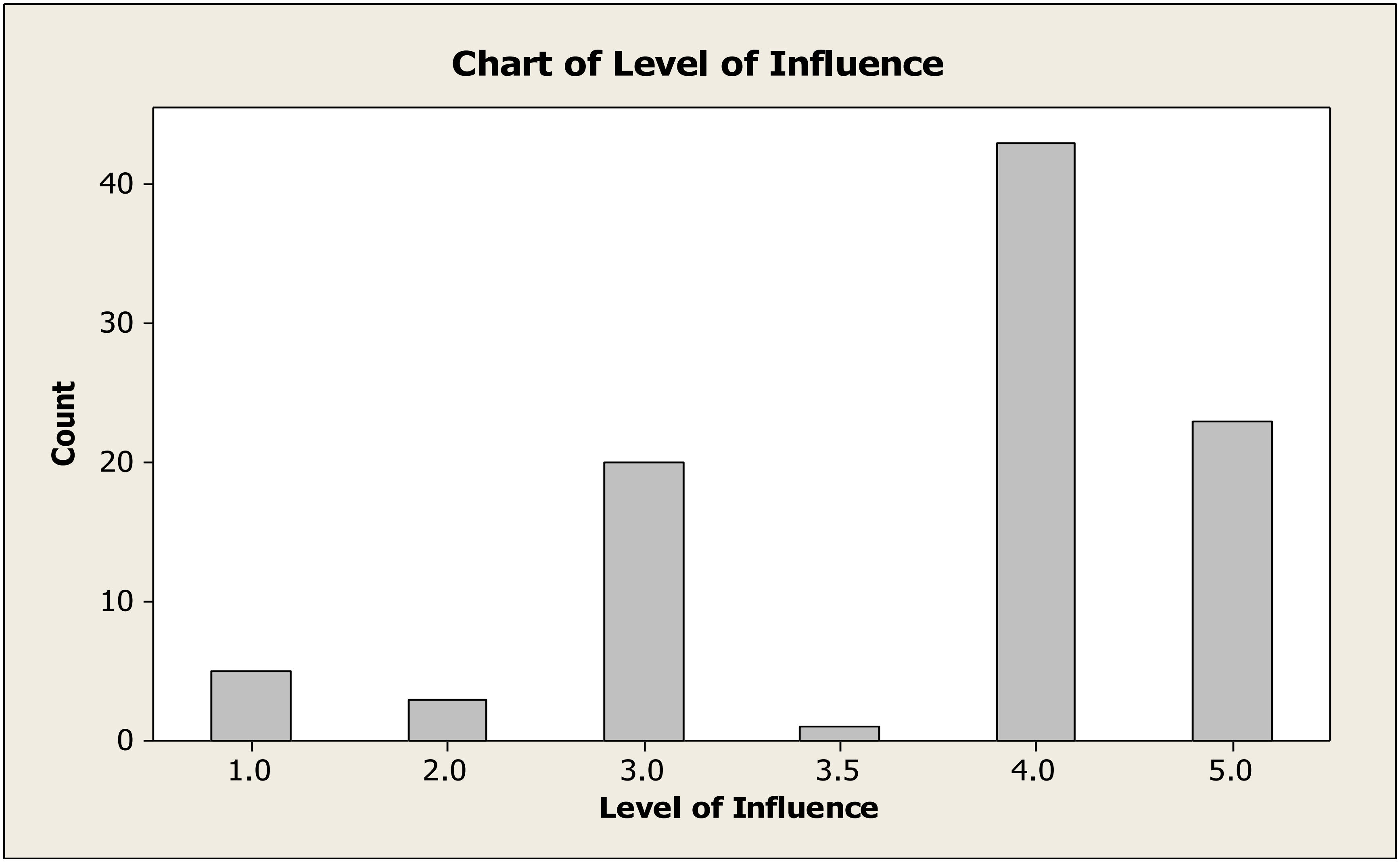


Figure 7.3: Level of Influence of deployment facilitator

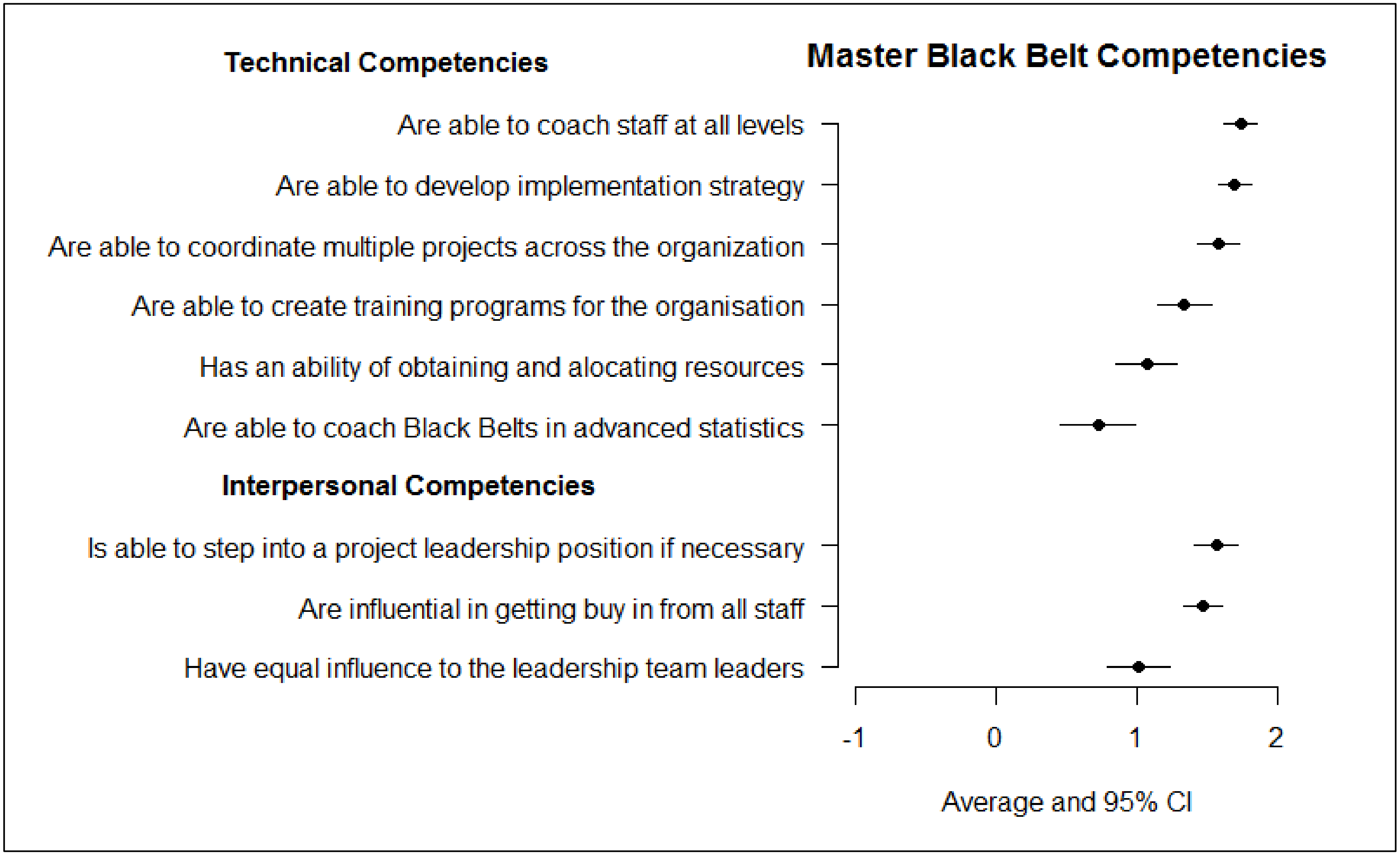


Figure 7.4: Confidence Levels for Master Black Belt Facilitator Competencies

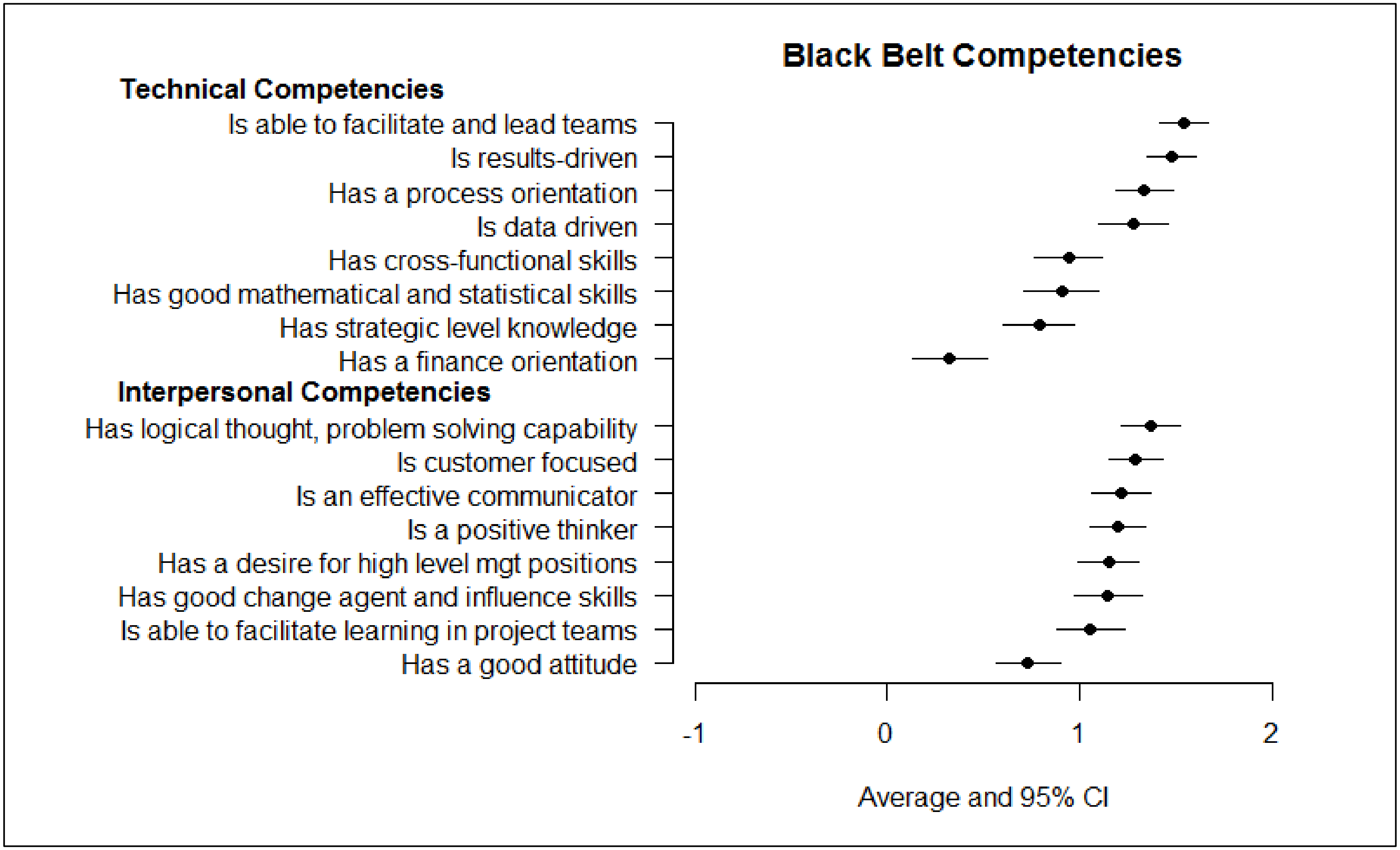


Figure 7.5: Confidence Levels for Project Leader Competencies

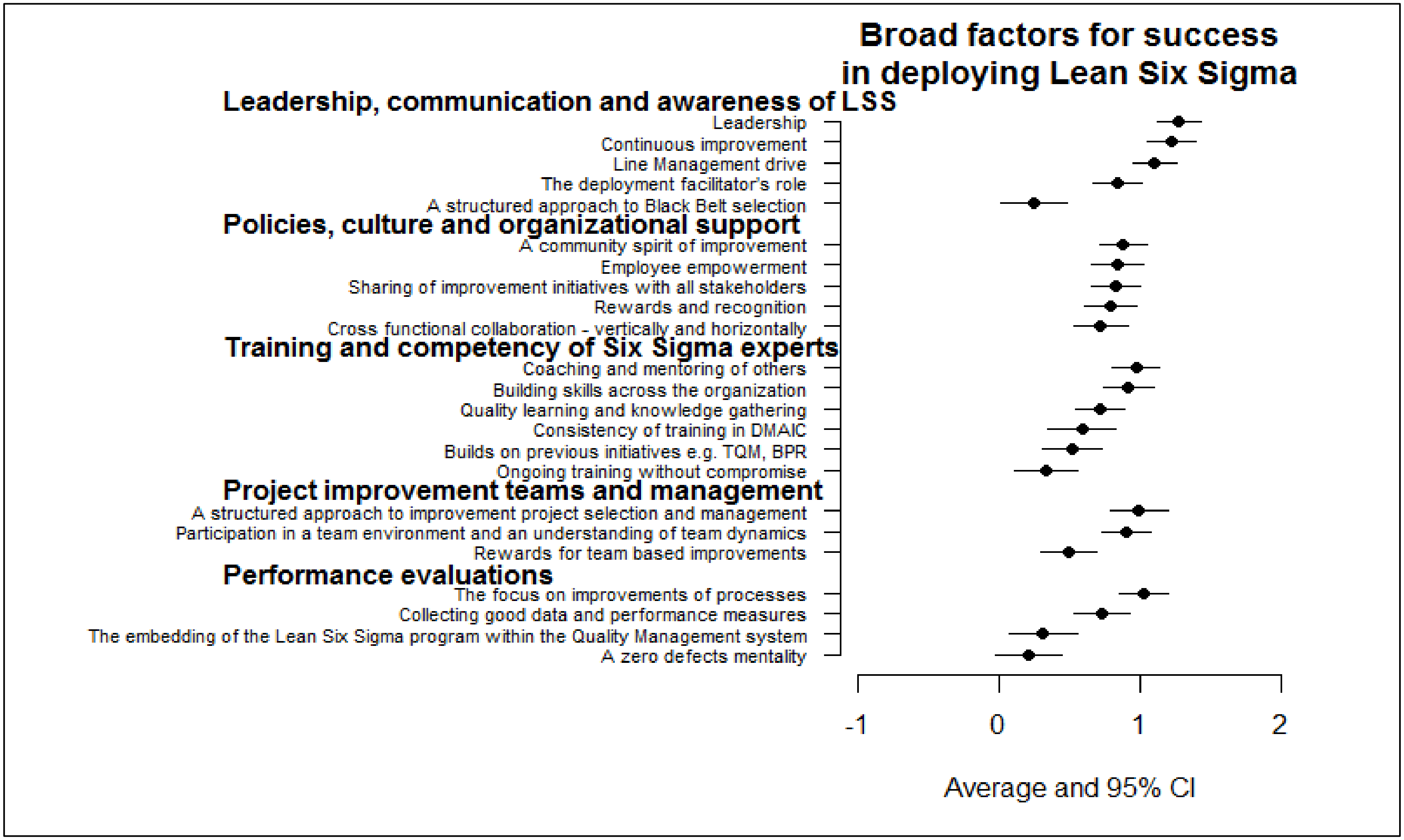


Figure 7.6: Confidence Levels for Organizational Competencies

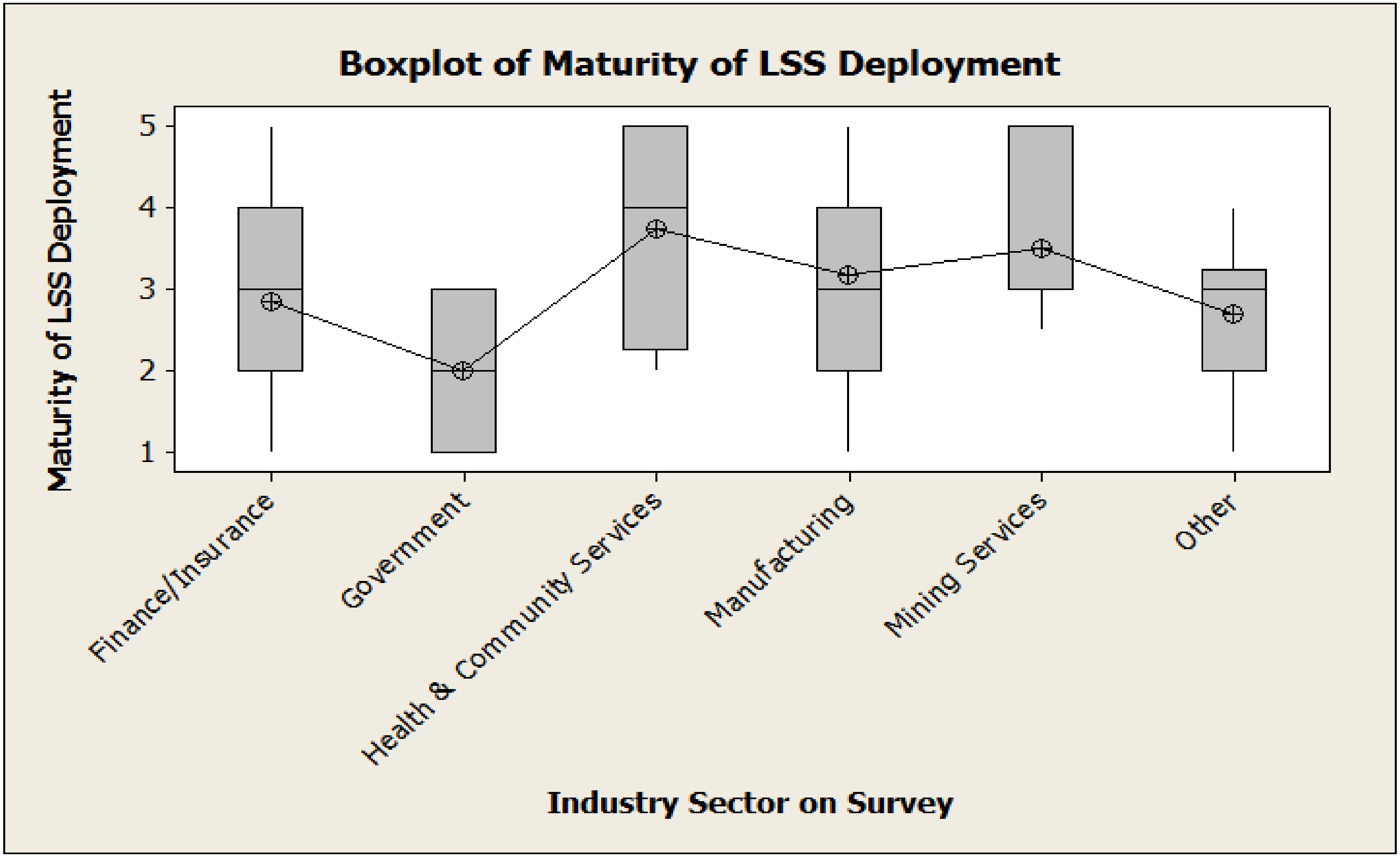


Figure 7.7: Program Maturity by Industry Sector

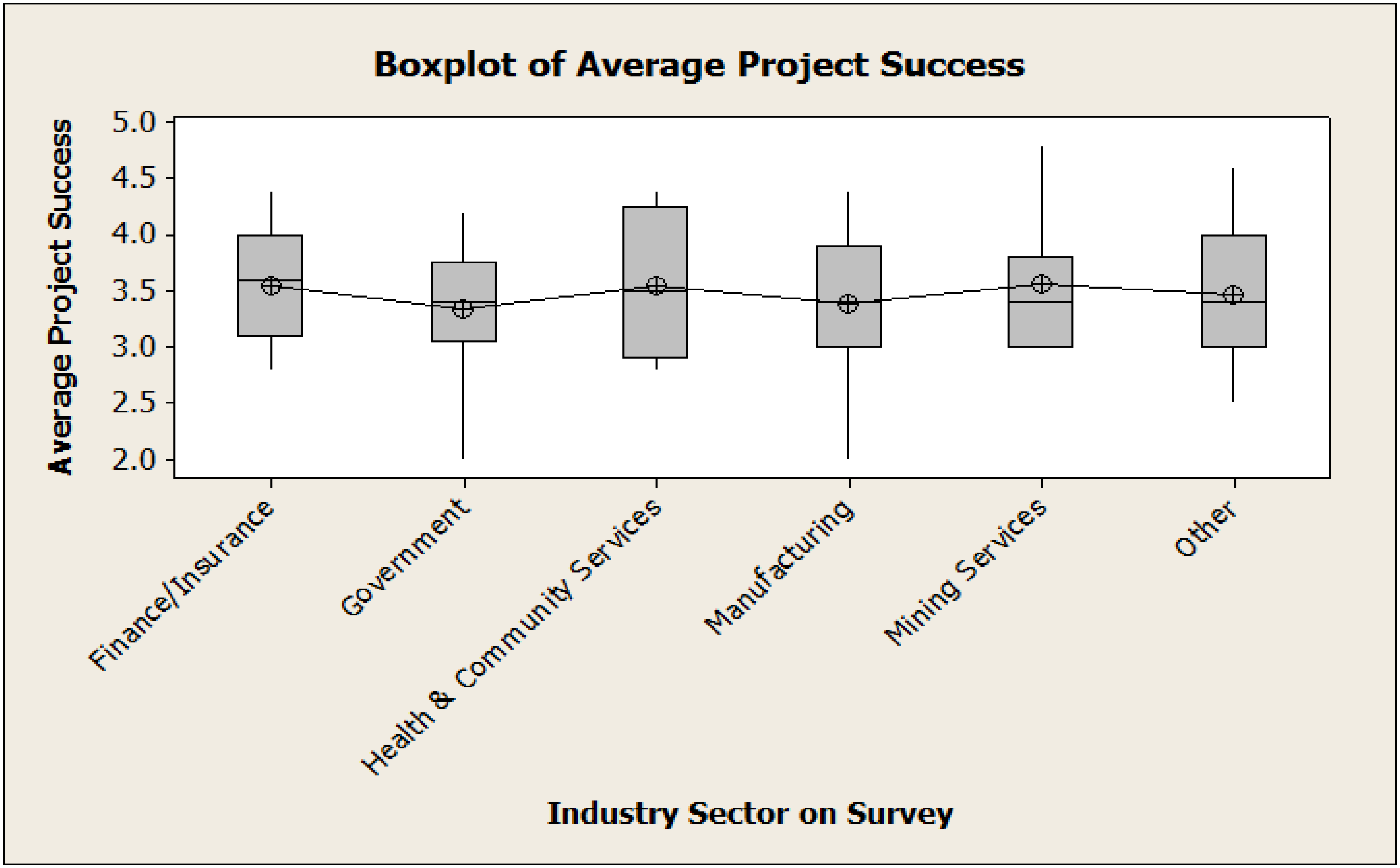


Figure 7.8: Average Project Success by Industry Sector

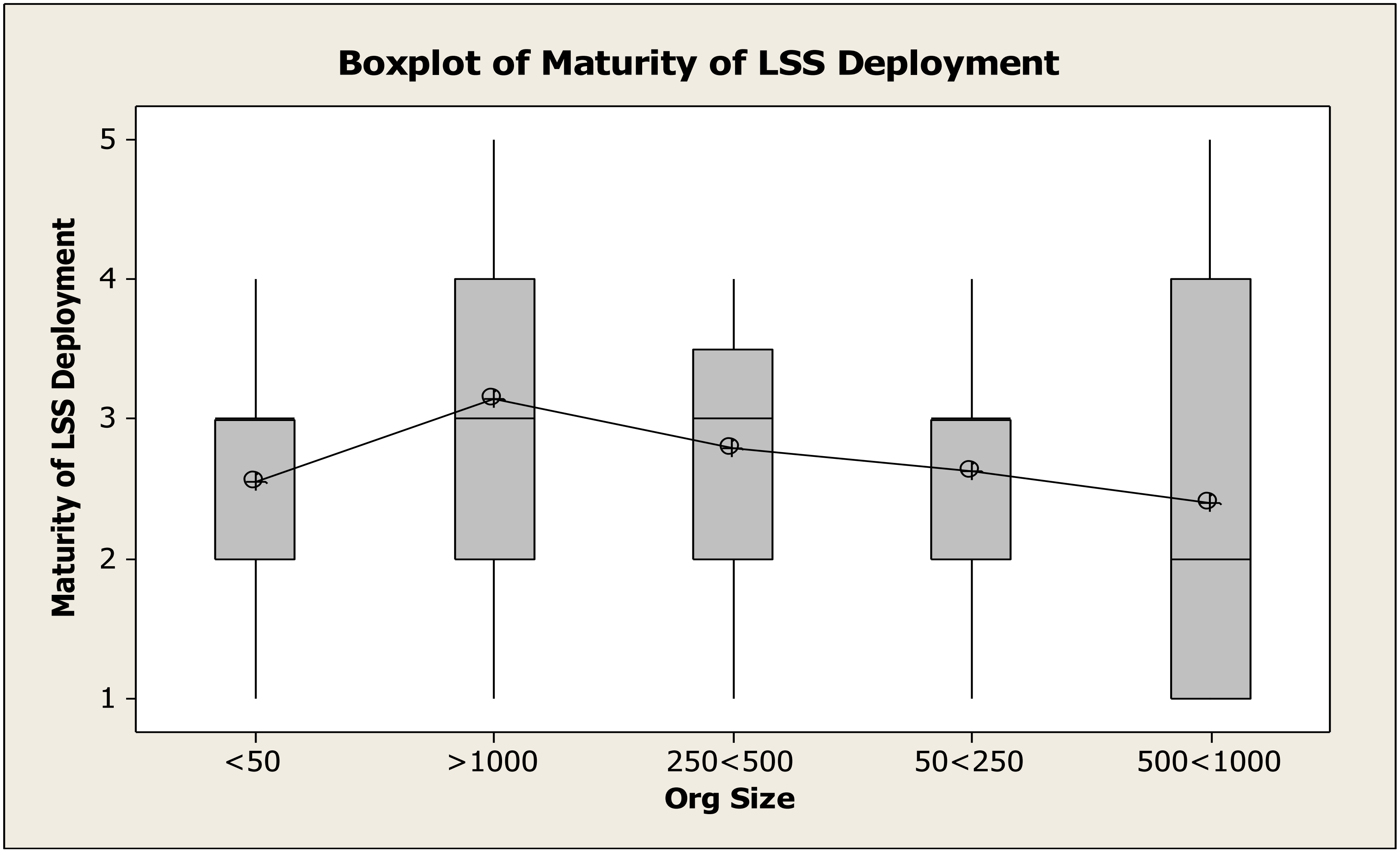


Figure 7.9: Program Maturity by Organizational Size

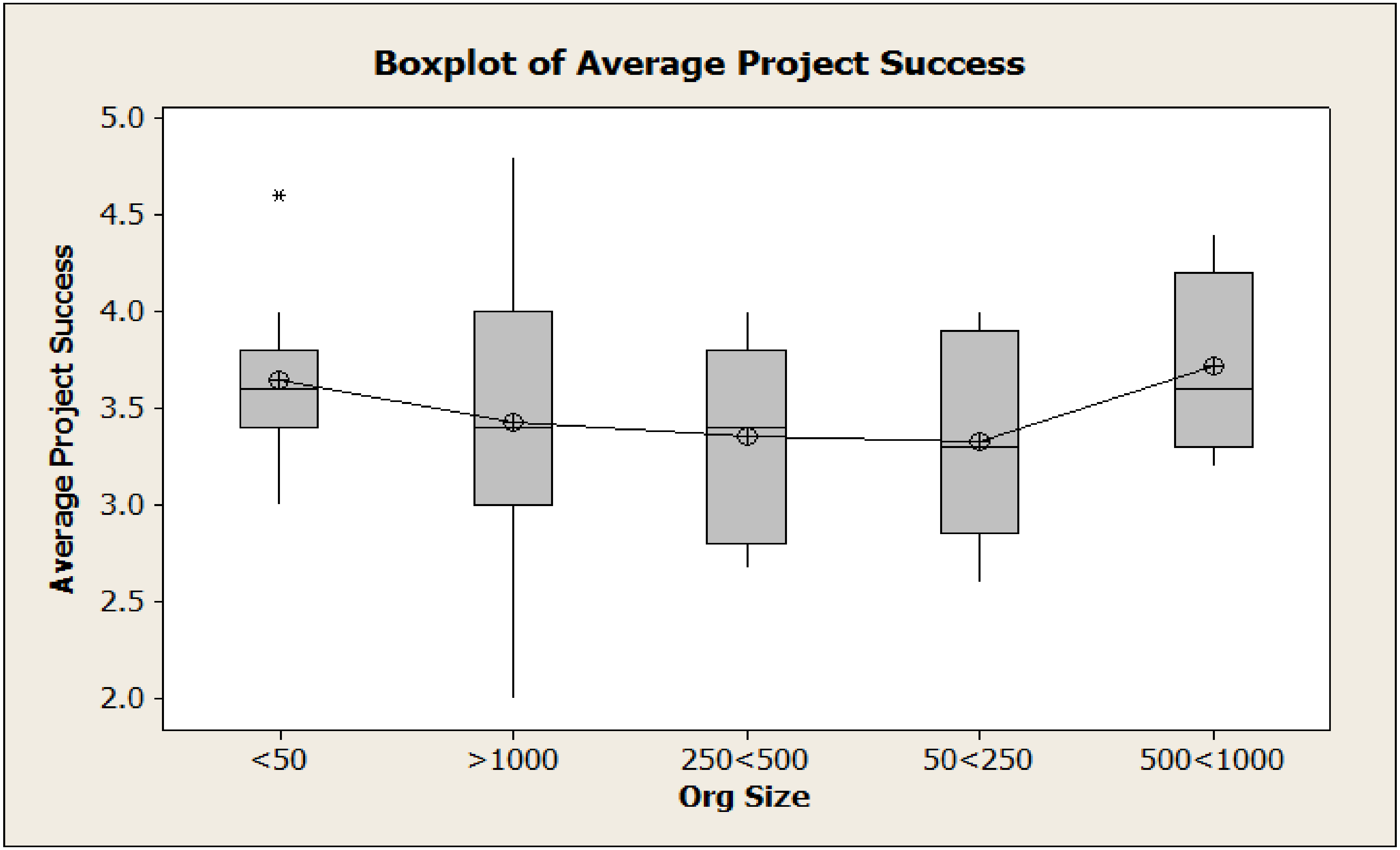


Figure 7.10: Project Success Organizational Size

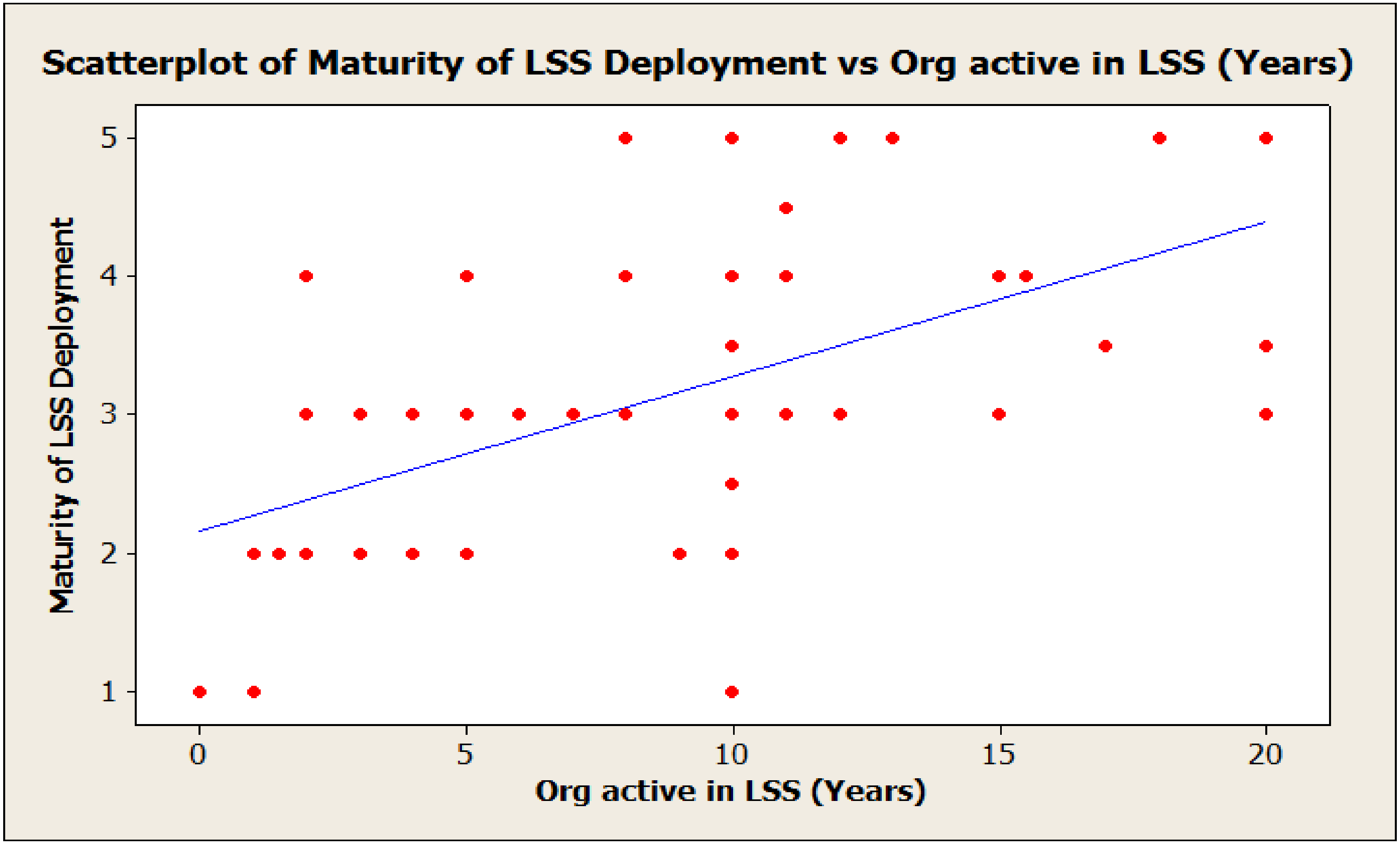


Figure 7.11: Relationship between Maturity and Years an Organization is active in LSS

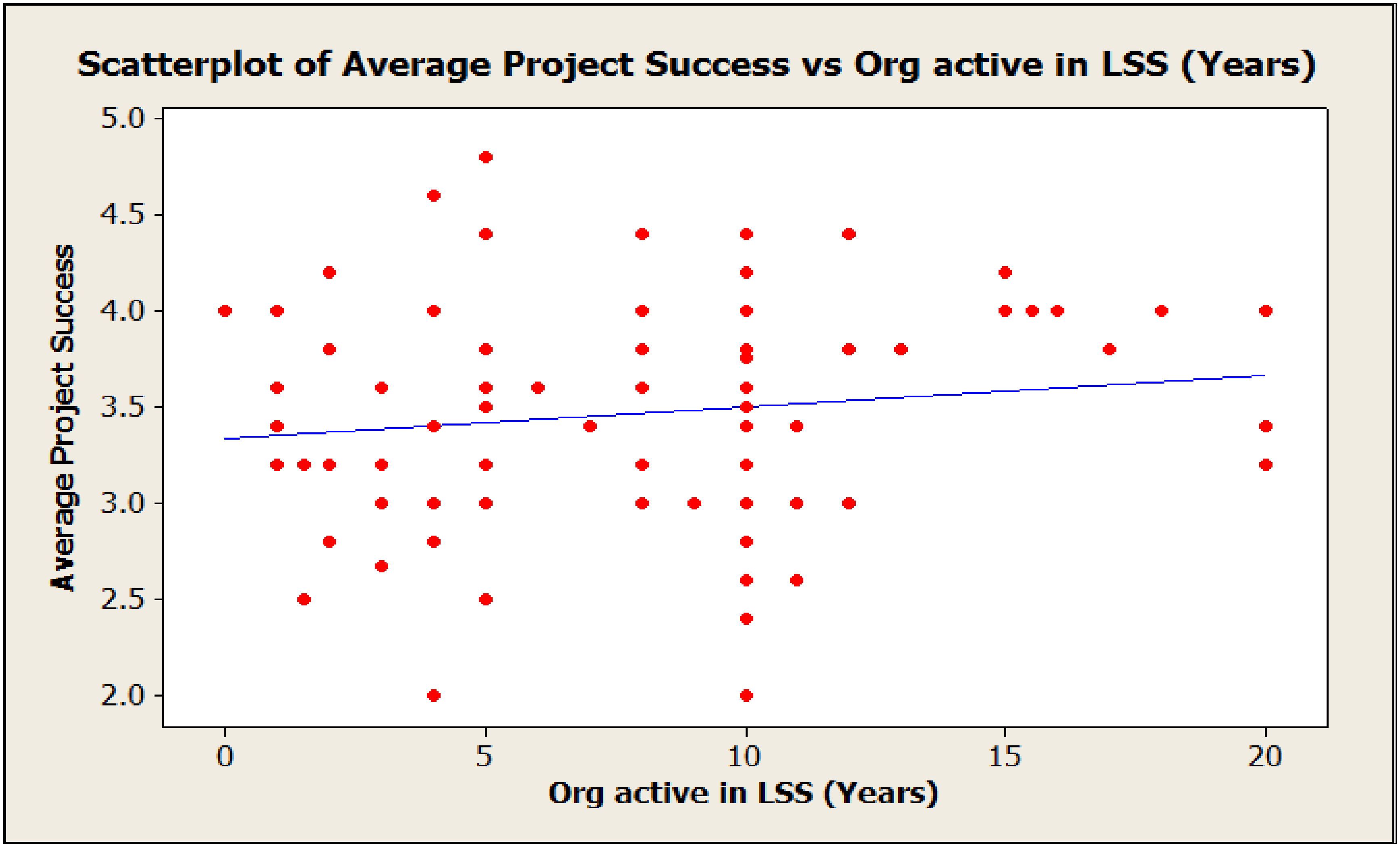


Figure 7.12: Relationship between Project Success and Years an Organization is active in LSS

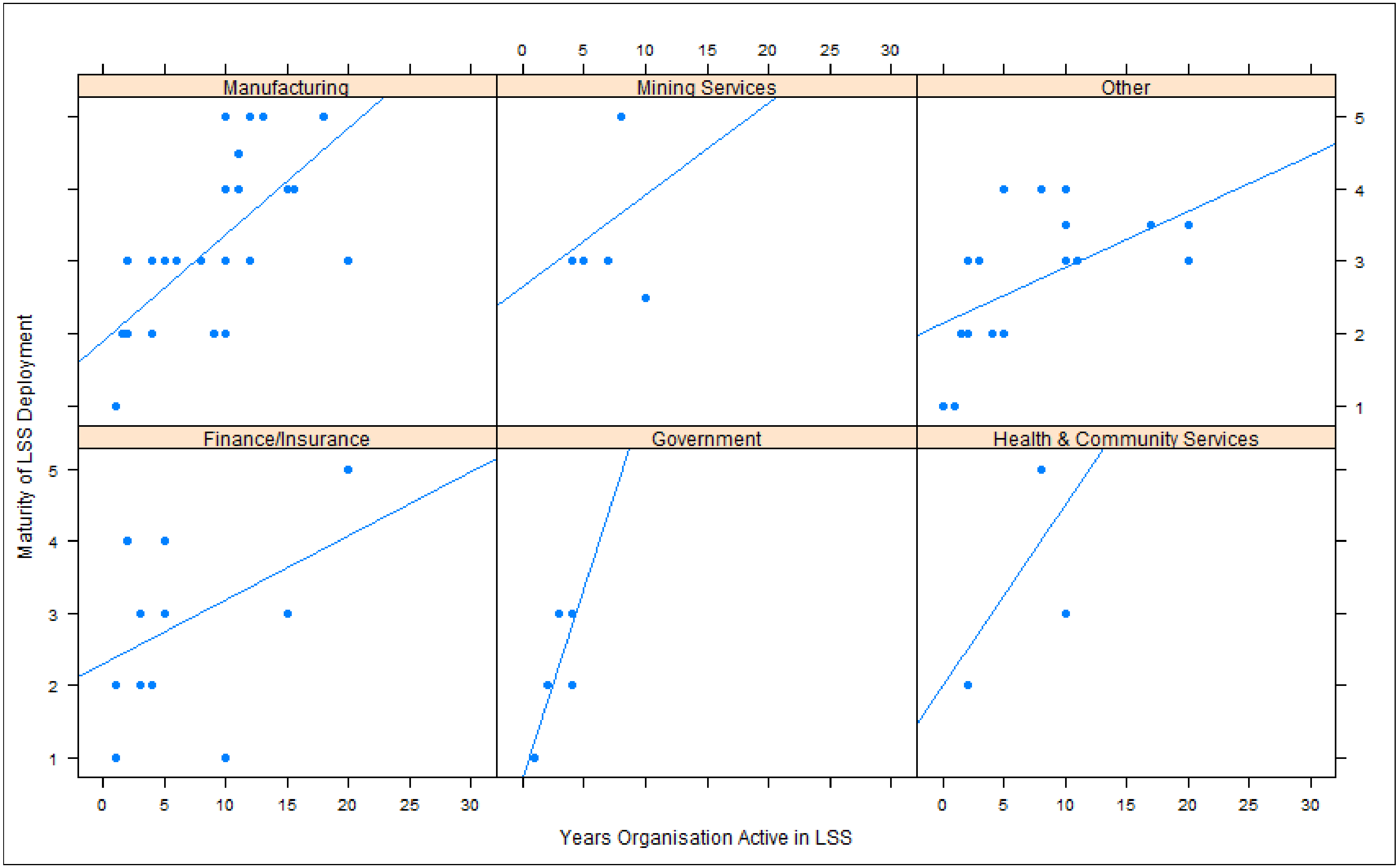


Figure 7.13: Program maturity versus Years an Organization is Active by Industry Sector

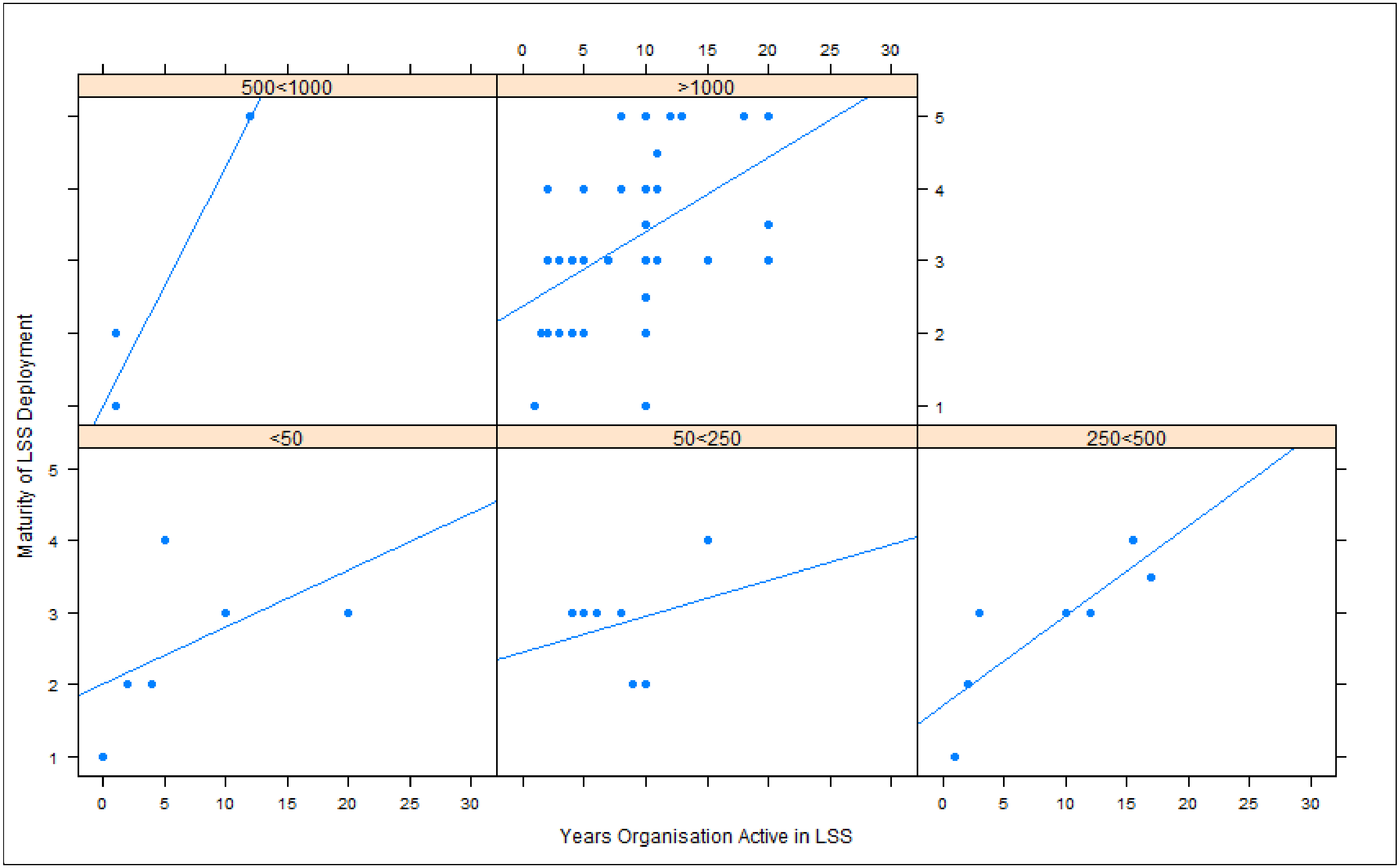


Figure 7.14: Program maturity versus Years an Organization is Active by Organization size

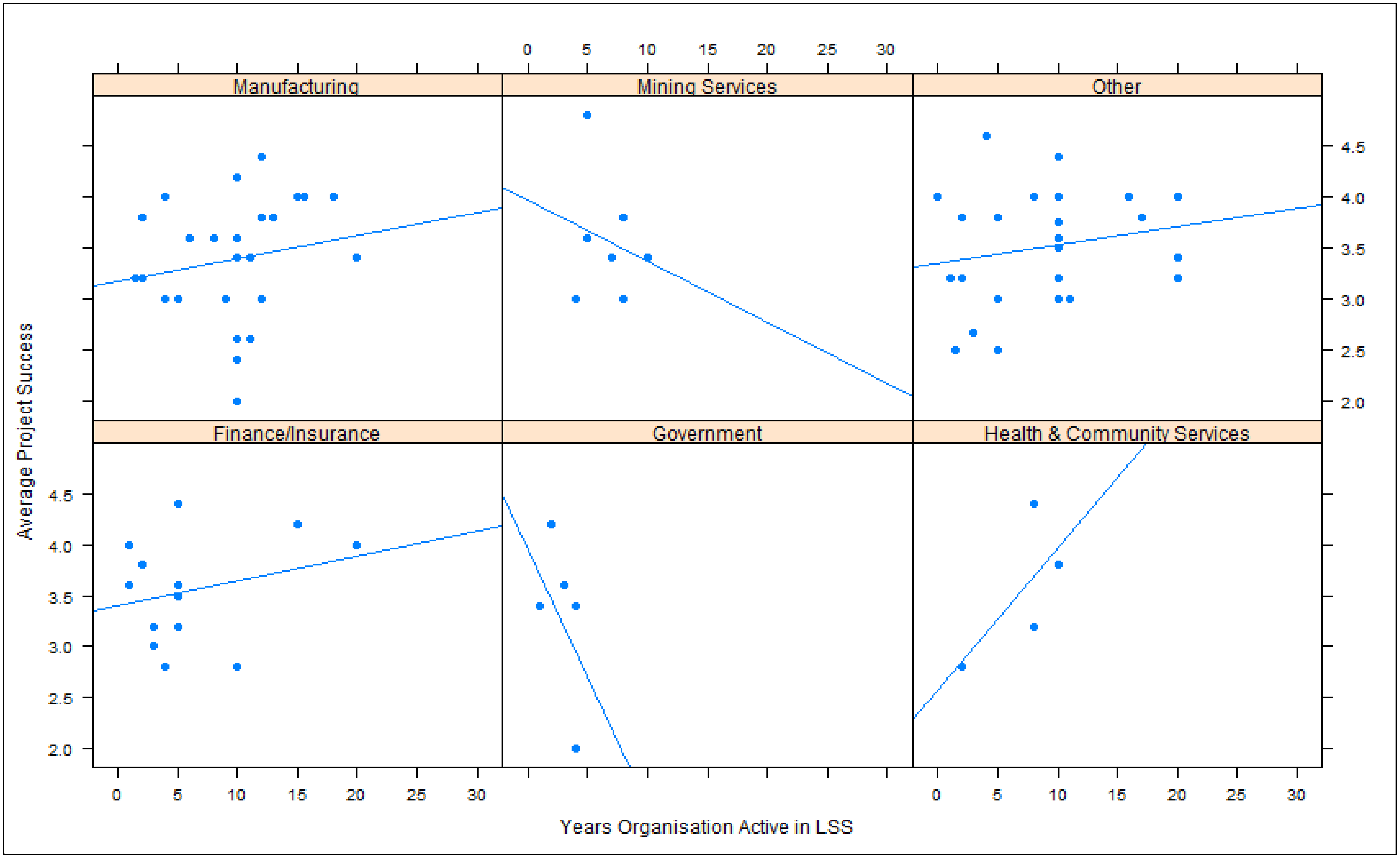


Figure 7.15: Project Success versus Years an Organization is Active by Industry Sector

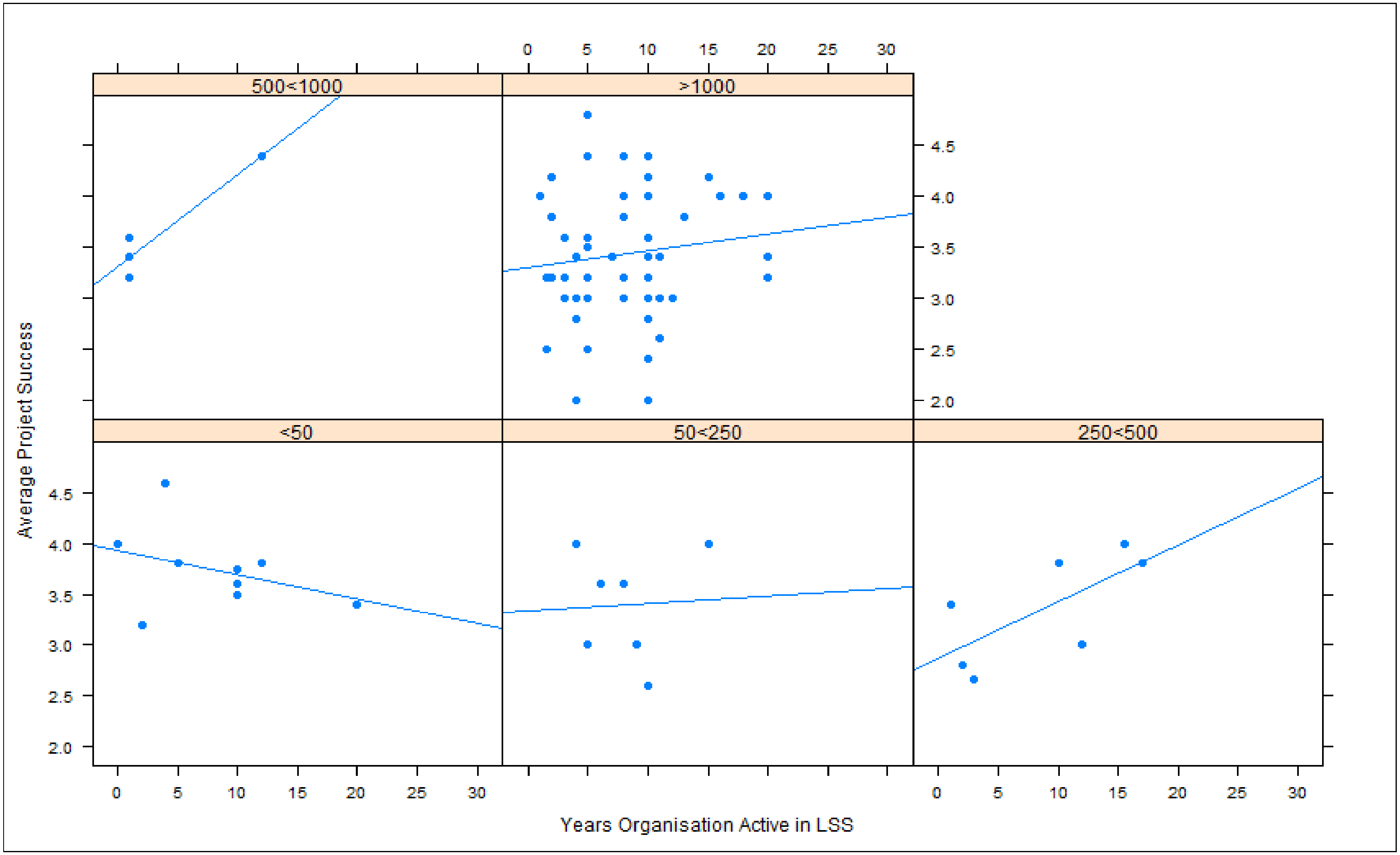


Figure 7.16: Project Success versus Years an Organization is Active by Organization size

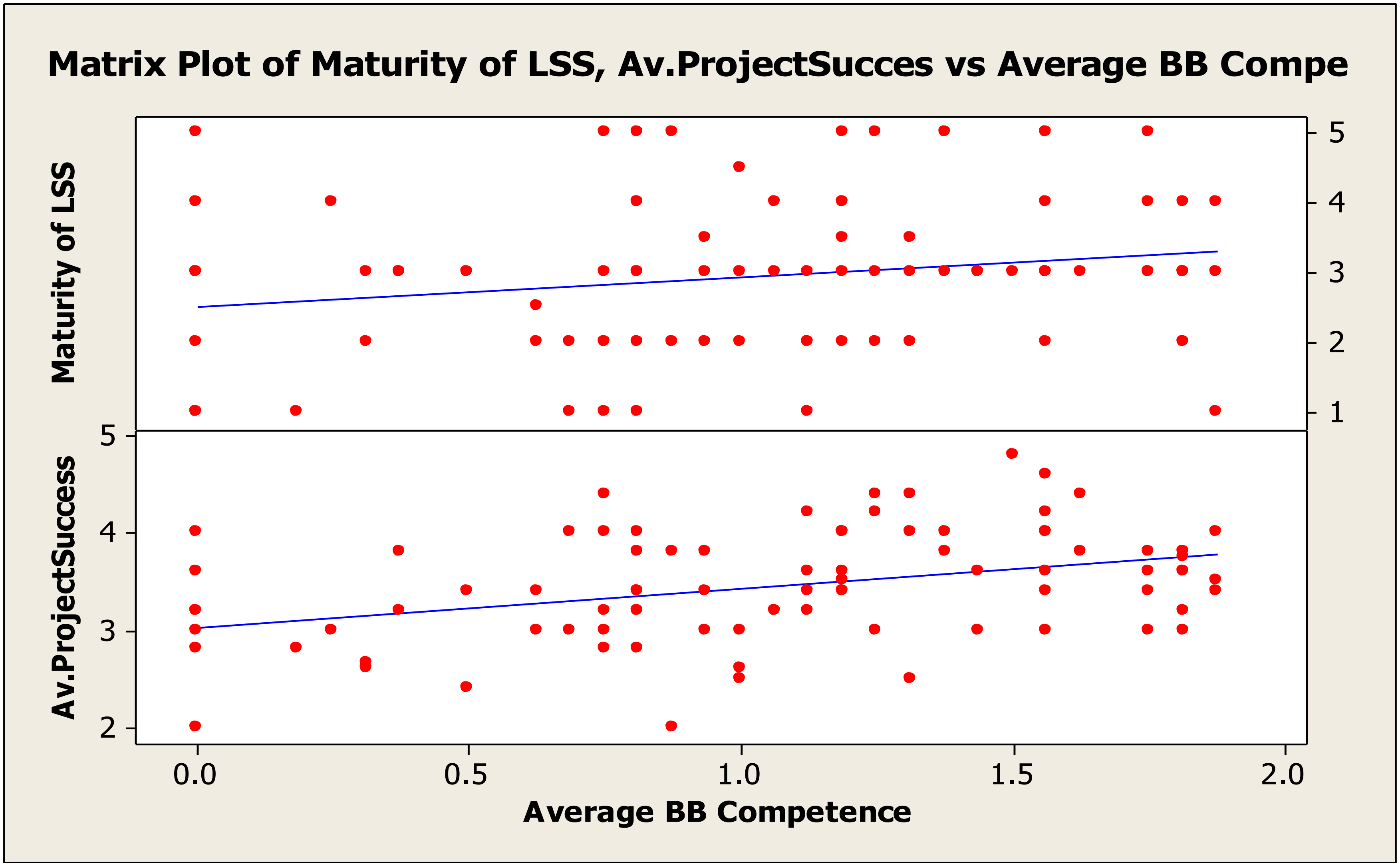


Figure 7.17: Program Maturity level and average Project Success versus average Black belt competence

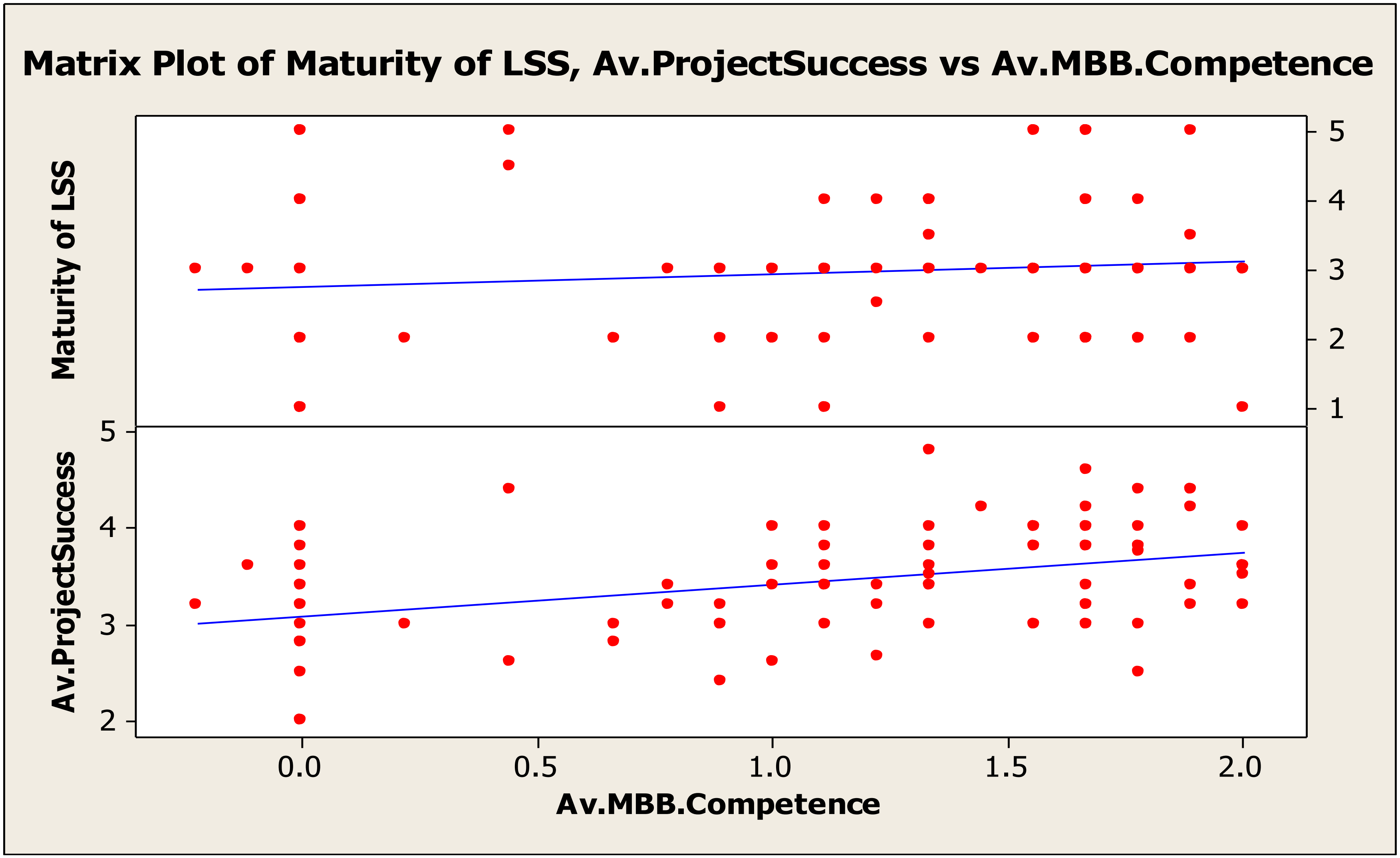


Figure 7.18: Program Maturity and Average Project Success versus average Master Black belt Competence

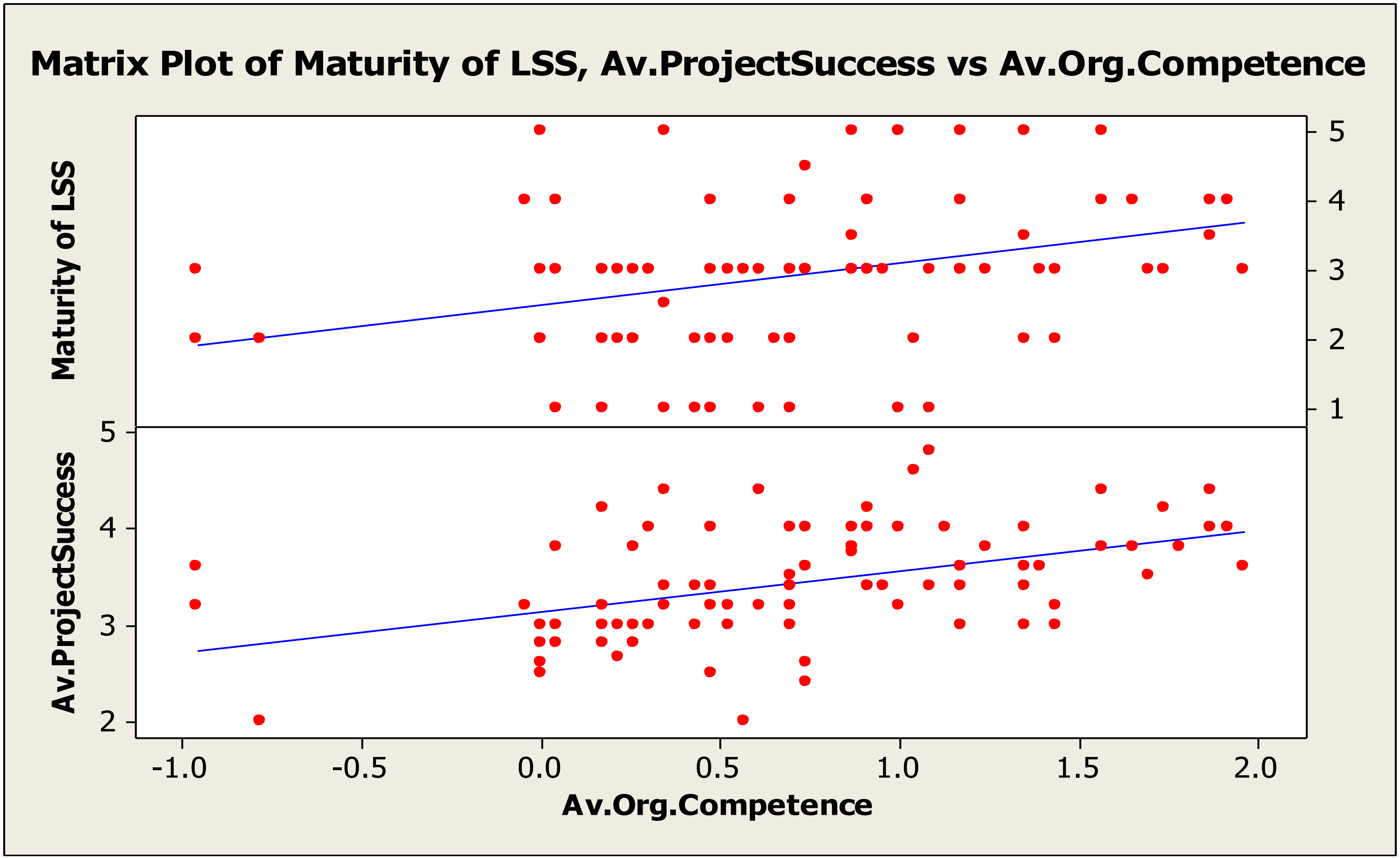


Figure 7.19: Program Maturity and average Project Success versus Average Organizational Competence

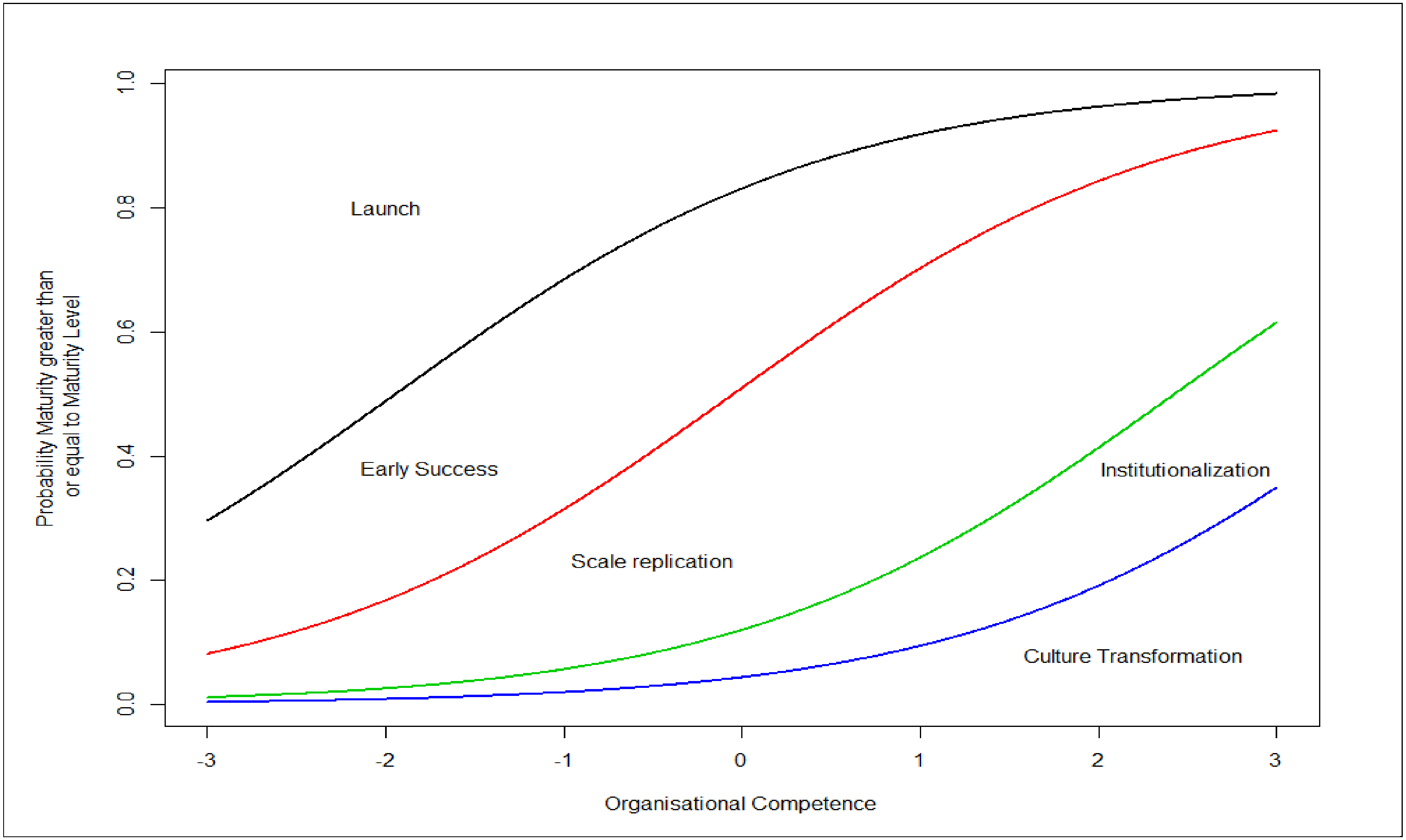


Figure 7.20: Program Maturity by Organizational Competence

## 7.6 Focus Group Summary

Once results had been summarized, it was decided to present the results to participants in a focus group. Three focus group sessions were arranged and held in Melbourne, Sydney and Perth where most respondents lived. The respondents were invited and about 20% of the cohort in each State accepted the invitation. An interesting point to be made is that about 30% of the respondents had moved organizations to other roles and could not be contacted between the date of the focus group invitation and the date when they completed the survey. Other Lean Six Sigma experts were also invited.

Generally, the comments regarding the research results were "consistent" across the three focus groups. During the focus group discussions, it was confirmed that project success was related to Black Belt competence. Black Belts do not need a financial focus (one of the competencies in Table 7.3) since they normally have access to external financial resources during a project.

It was also noted that the more senior the Master Black Belt or LSS facilitator is, the more influential the role can be. One attendee suggested that the selection of candidates for training is not very structured across many companies that she had been involved with.

A number of other insights were obtained regarding maturity of a Lean Six Sigma deployment. A summary of the key points on maturity from the people attending the focus groups are presented below.

- To strive towards a maturity level of culture transformation (level 5) seems to be an "ideal" than a business driven requirement
- The results show that current business practice is capping program maturity (regardless of industry type) at 3.5 (Calculated in the results) on the maturity scale and that scale replication coupled with on-going project success seems to be meeting business needs

- Cultural transformation is a 5 year plus proposition and Australian culture is more a 1 to 3 planning horizon, which makes scale replication capable of delivering on an ever-growing demand for quick wins
- In balancing up the books between the total cost of quality, the controllable cost of quality and the investment (both in dollars and time horizon) required from companies to ingrain Lean Six Sigma, if project success does not change as organizations become more active and total cost of quality is not visible, it's not a 'no-brainer' for businesses to want to move past scale replication, especially given a charismatic project leader and a Lean Six Sigma light tool box (more Lean and use of simple statistics) can deliver on-going project success
- It's almost a case of diminishing returns - business seems to regard the investment required to achieve the last 30% of project maturity as not yielding the rewards
- Immature organizations will start with easier projects which should have a high rate of success
- As an organization becomes more mature they will tackle more ambitious projects which may naturally have a higher rate of failure
- As an organization becomes mature the measurement of success becomes more self-critical – at the start there is a temptation to declare success which can occur from both taking the easy wins and maybe also some element of self-justification
- The hurdle for measuring success may naturally move to maintain alignment with maturity
- Project success in the short-term is easy but institutionalization in the long term is hard
- Some candidates boosted their career prospects with the certification & then left the organization.

## 7.7 Summary of Results

The results of the analysis presented in sections 7.5 and 7.6 provide a number of insights into the sustainability of Lean Six Sigma. In this section, the key insights are summarised.

A Lean Six Sigma deployment can be organization-wide, project based and top-down driven and is usually about the delivery of operations excellence foundations to all levels of organization. The most common model deployed is one which involves both Lean tools and simple statistical tools.

Although the respondents are well qualified both academically and in Lean Six Sigma and have facilitated a large number of projects, a noticeable lack of competency exists in an ability to coach others in advanced statistics. The respondents did not rank their influence level as high as the leadership team although the average influence level was high for the sample.

The technical and interpersonal competencies that were not ranked high for a typical Black belt should provide a basis for understanding the gaps in Lean Six Sigma training at Black Belt level.

Organizational competencies that are not well supported are contrary to the expectations of other academics research, for example embedding the program in a quality management system is a critical factor for success as noted in Pfeifer et al (2004). The organizational competencies that are not well supported where the confidence interval lower bound is less than 1 appear to be inconsistent with some of the expectations of the philosophies of Deming, Crosby and Juran (Powell, 1995) and may explain the lack of maturity of a Lean Six Sigma deployment.

Program Maturity level is lower for organizations that have had less time being active in Lean Six Sigma but manufacturing organizations have not gained in maturity compared to Health and Mining services organizations considering the manufacturers have been active in Lean Six Sigma over a longer time on average. Average Project success is not significantly different across industry sectors.

Program Maturity level varies across organizational size. In particular, for organizations of sizes greater than 1000 the maturity level is higher than that for other organization sizes. Average Project Success is consistent across all organizational sizes.

Program Maturity level is significantly and positively related to the number of years that an organization has been active in the program and this makes practical sense. Average Project Success does not change significantly as an organization becomes more active in Lean Six Sigma implying that projects are just as successful when the program is launched.

For different organization sectors and organizational sizes, the relationship between program maturity and Years active is still positive and increasing. When the organization sector and organizational size are considered separately, the relationship between average Project Success and Years active varies across sectors and organizational sizes. This may be due to sample size and Program Maturity level.

Program Maturity level increases slightly with the influence level of the deployment facilitator but average Project Success is significantly related to the level of influence of the program facilitator implying that the facilitator has more impact on project success than maturity.

Average Black Belt competence significantly impacts Program Maturity and has a strong relationship with Project Success. Average Master Black Belt competence does not impact Program Maturity level but has a significant positive impact on Project Success. Average organizational competence significantly impacts the Program Maturity level.

A Multiple Regression shows that Program Maturity level versus average organizational competence, average Black Belt competence and average Master Black Belt competence is significant and the coefficient of average organizational competence is the only one significant.

Multiple Regression of average Project Success versus the same explanatory variables is also significant and average organizational competence is very significant. Splitting the Master Black Belt and Black Belt competencies into technical and interpersonal has less effect.

Program maturity is positively and significantly related to project success and this reflects that average Project Success improves as an organization becomes more mature at Lean Six Sigma.

## 7.8 Summary of chapter 7

This chapter presents the results of fieldwork phase 4. The survey instrument is explained and validated, results are presented, a summary of the focus group comments is presented and a discussion of the results is presented.

# 8. Chapter Eight: Discussion of Results

## 8.1 Introduction

In this chapter, a discussion of the key findings from this research into the sustainable deployment of Lean Six Sigma is presented. This discussion includes a comparison and analysis of the key insights obtained from the literature review presented in chapter 2, the face-to-face interviews using semi-structured questions presented in chapter 4, the in-depth analysis of the organization in Healthcare presented in chapter 5, the open questionnaires presented in chapter 6 and the National Survey presented in chapter 7. The key findings are presented using the topic headings that link to the five research questions and the developed model for sustainable deployment of Lean Six Sigma.

## 8.2 Key drivers and success measures

In the literature review, the key drivers of Lean Six Sigma are at two levels – operational level drivers (Shah *et al.*, 2008) and organizational level drivers (O'Rourke, 2005). The assumption by many organizations seems to be that a focus on the operational drivers will lead to success at the organizational level or success at the operational level is "good enough".

Measures of success at the operational level through projects may not necessarily lead to success at an organizational level although this appears to be contradictory in the literature. According Goh and Xie (1994), improved process capability will mean that defect rates are lower and customers are satisfied and sales are likely to grow. However, organizations may improve cycle time and process capability but may not yield bottom-line savings. Again, this creates a varied impression of the success of Lean Six Sigma according to which indicator is selected. For example, if the success measure is increased savings then Six Sigma has been shown to be effective (Pande *et al.*, 2000) but when stock price is the indicator, then it is not so clear (Goh *et al.*, 2003). When corporate competitiveness is the measure, Six Sigma has been shown to be successful (Lee and Choi, 2006). Pyzdek (2004) suggests, during a chat room discussion, when a Six Sigma project shows bottom-line savings, there is no guarantee that the organization will be successful in the market place.

Organizations may improve cycle time and process capability but may not yield bottom-line savings. This creates a varied impression of the success of Lean Six Sigma according to which indicator is selected. This is a key finding in this research.

Also, success at an operational level may not be sustainable. A clear definition of performance is critical to agree and set before an assessment is made of the success of the deployment since a company could fail in organizational success metrics like competitive advantage or higher market share from a Lean Six Sigma program but excel in project improvements in an operational metric like quality or responsiveness.

Success of a Lean Six Sigma deployment can include project success but also should include a measure of the level of maturity of the deployment. Organizational level measures tend to be long-term measures whereas, operational level measures used in projects tend to be measures for the short-term unless there is some level of maturity of the organization to ensure that the measure can be continually improved. For example, obtaining competitive advantage and a higher market share is partially influenced by the Lean Six Sigma project success and partially how mature the organization is and how well it supports various organizational and personal competencies (Goh *et al.*, 2003; Huq, 2006; ISO13053, 2011; Moosa and Sajid, 2010; Raje, 2009).

From the results in fieldwork phase 1, key drivers of Lean Six Sigma for the seven organizations range from operational and organization-wide goals. The drivers tend to vary across the industry sectors represented. For example, it is noted that there is pressure on manufacturers, especially the SMEs cases in the automotive supply chain, to continually reduce costs and focus on improvement using methodologies like Lean Six Sigma and involve the supply chain (suppliers and customers) in their improvement activities. The larger case organizations have pressure to deploy continuous improvement due to local and international competitive pressures although with larger financial resources this allows more flexibility. SME cases tend to look for assistance from Federal Government funding with respect to training of employees in Lean Six Sigma.

In fieldwork phase 1, the case in Healthcare is driven to improve in all their services in order to demonstrate innovation and cost reduction in their processes, which is usually rewarded by increased State Government funding. The Bank case has a focus to improve customer service, increase market share and create a culture of improvement. However, a driver for all cases in fieldwork phase 1 was to develop capability and empower employees across the organization. For case 6 (a large international organization providing Information Technology services in Australia), it was about creating a culture of improvement but for the manufacturers (cases 1, 2, 4 and 5), it was enhancing their current improvement cultures.

Drivers noted in fieldwork phase 1 clearly can be allocated to either of the two categories – operational or organizational. This is another key finding of the research.

Comments by one of the respondents in fieldwork phase 4 suggested that a key driver for Lean Six Sigma in manufacturing was "the need to become a great company in operational excellence rather than the need to rescue and survive in the future". This is an organizational level driver since it relates to perception of the organization rather than anything to do about operations (although operations success can deliver operations excellence).

In the literature review, success measures at an operational level include, for example, reduced cycle time, improvement capability, savings or reduced costs and at an organizational level include, for example, higher profitability, improved market share or improved customer service. During the face-to-face interviews in fieldwork phase 1, success measures were specifically defined by the participants (question 7, appendix A1) and these measures supported and, in some cases, expanded the concept of success. Nevertheless, these were both at an operational and organizational level and included:

- Project Schedule adherence (number of projects completed)
- Quality (Less rework/defects)
- Process Efficiency (Improved cycle time)
- Responsiveness (Improved service delivery)
- The number of trained Lean Six Sigma practitioners
- Satisfaction level of the employees
- Savings resulting from project work
- Improved market share
- Customer satisfaction level
- Cultural impacts
- More collaboration in the supply chain, and
- Customer awards

Specifically for case 5 (a large international company based in metropolitan Melbourne supplying parts to the automotive industry) in fieldwork phase 1, it was noted that overall performance was difficult to measure as it is part of other quality initiatives and initial costs of the program are high relative to success, that is project costs and training costs are higher than project outcomes. This implies long-term measures are not as easy to evaluate and generally success or failure of an improvement program can be blurred.

From the results in fieldwork phase 4, additional success measures identified by the respondents were:

- Sustainability
- Resources committed
- Long-term gains
- Employee engagement
- Six Sigma process compliance
- Return on Investment
- Safety.

These tend to be measures at the organizational level and in particular, the additional measures of sustainability and long-term gains support the notion of the inclusion of maturity level in the definition of success – a further key finding.

## 8.3 Deployment strategies and models

This section presents a discussion on the findings of how Lean Six Sigma has been deployed.

In the literature review, linking Lean Six Sigma to the strategy of the business by aligning projects, people and processes is the intent of Lean Six Sigma deployments (Yacovone, 2007). Deployment can be top-down/company-wide, partial in a business unit or process focused. Pilot projects can reduce the risk during deployment (Gates, 2007; Shanmugam, 2007). Divisional level rather than company-wide deployments are more common in service because of the size of these organizations.

In fieldwork phase 1, the deployment is either an organization-wide philosophy or a project-driven approach. For example, for case 1 (a medium-sized Australian assembler based in metropolitan Melbourne supplying parts to the automotive industry), case 2 (a medium-sized division of a multinational organization based in country Victoria supplying castings to the mining industry) and case 7 (a Hospital based in metropolitan Melbourne providing Healthcare services), it is a project approach and for case 3 (a large Australian Bank), case 4 (a medium-sized manufacturing based in country Victoria supplying parts to the Truck industry), case 5 (a large international company based in metropolitan Melbourne supplying parts to the automotive industry) and case 6 (a large international organization providing Information Technology services in Australia), it is an organization-wide approach.

Also in fieldwork phase 1, all the deployments have tended to be top-down. The manufacturers have a project focus as well, the SME's find it easier to employ across the company whilst larger companies can struggle with this.

The likelihood of deployments for SMEs training a number of Black Belts is low because of the cost of this training is prohibitive (Davis, 2003). Improvement projects for SMEs need to be focused on successful outcomes due to a lack of resources being allocated full-time (Davies, 2005; Wessel and Burcher, 2004). This was supported in fieldwork phase 1 where selected staff in case 1 and case 2 (SMEs) were still working as team leaders but were trained to Yellow Belt level in DMAIC and the training was funded.

A “Belt” infrastructure of Master Black Belts, Black Belts and Green Belts is more prevalent in the larger companies because of the larger investment in training because of the high cost of training for SME’s. This is consistent with fieldwork phase 1 for case 3 (a large Australian Bank), case 5 and case 6 having a Belt infrastructure. For the SME’s the resources available to train the “Belts” are limited and this is consistent with the literature.

For some organizations represented in fieldwork phase 4, a Lean Six Sigma deployment can be project-based and top-down driven and in others it is about the delivery of Operations Excellence foundations to all levels of organization, with particular focus on "first touch" staff.

TQM is still used in many sectors and has been combined, in some sectors (Banking), with Lean Six Sigma (Bin Jumah *et al.*, 2012). Lean Six Sigma has been leveraged off TQM, acknowledging that TQM was successful in some areas. In fieldwork phase 1, many of the cases deployed previous quality initiatives like TQM and quality circles without success mainly because improvements were not able to be financially measured.

In the literature reviewed, the deployment of Lean Six Sigma in service has been slower and Lean is the predominant model since good data is lacking (Johnson *et al.*, 2004; Ray and Boby, 2011). It has been deployed without a theoretical foundation but has been modeled on manufacturing. The order of deployment of Six Sigma and Lean in service varies (Patton, 2005).

In the review, the tools within the phases of DMAIC for Lean Six Sigma have not been clearly stated but appear to have been based on Six Sigma phase tools with Lean added where appropriate. In particular, it is clear that the phases of a Six Sigma methodology are well-defined but there has been little attention given to the definition of what constitutes a Lean Six Sigma methodology (Gershon and Rajashekharaiah, 2011). Lean Six Sigma has been described in various research articles but it has been essentially described as Six Sigma with Lean added (Arnheiter and Maleyeff, 2005; Pepper and Spedding, 2010; Snee, 2010; Souraj *et al.*, 2010). For example, in many companies Lean Six Sigma deployments use the DMAIC methodology and also use Lean tools at various stages and in others Lean is separately deployed concurrently with DMAIC. Further, the use of tools will vary within the DMAIC phases based on the project focus and amount of data available (Mader, 2008).

In the review, some companies have deployed Six Sigma first then Lean and other companies have deployed Lean first to identify low-hanging fruit and then implemented Six Sigma and others have implemented the combined program from day one (McIlroy and Silverstein, 2002). In fieldwork phase 1, all cases have tended to identify low hanging fruit first whether or not Lean or Six Sigma was the initial focus. In fieldwork phase 4, some organizations have a mixture of models ranging from Lean only through to the use of advanced statistical tools. The latter is more common in manufacturing organizations where data is prevalent.

The DMAIC methodology is commonly used across the organizations in fieldwork phases 1 and 4. This is consistent with the Lean Six Sigma Light model of Mader (2008) for all organizations and Johnson, Shanmugam, Roberts, Zinkgraf, Young, Cameron and Flores (2004) for Healthcare specially. In fieldwork phase 4, the use of simple statistical, quality and Lean tools in the DMAIC phases is more common across all industry sectors. This is consistent with the results in fieldwork phase 1 in which all cases use these simpler tools within DMAIC. For case 5, the tools used in the phases vary across the cases from 5S and line balancing to complex experimental design in the Improve phase; from cause and effect diagrams to complex regression analysis in the Analyze phase.

In fieldwork phase 4, respondents commented on the deployment strategies and models of their organizations. These comments supported the notions that:

- Many of the deployments start with Lean first then Six Sigma to obtain quick wins
- Lean is becoming more popular in focus because of its simplicity and Six Sigma is not easily implemented into a data-poor environment, like service
- Lean Six Sigma is still very top-down but project based and it is about the delivery of operations excellence foundations to all levels of organization, with particular focus on "first touch" staff
- Application of Lean Six Sigma in large organizations is different than in an SME mainly due to the availability of resources

The focus on Lean or Six Sigma seems to be based on the interests of the deployment facilitator. This is consistent with the work of Shah *et al.* (2008). For example, the facilitator in case 1 is passionate about Lean and so the employees tend to use more Lean tools than Six Sigma tools. In case 2, the facilitator is a trained "Yellow Belt" and therefore tends to encourage the use of simply statistical and data collection tools within the DMAIC phases. In case 3, both facilitators are knowledgeable across Lean and statistics so the Lean Six Sigma Light model (Mader, 2008) is the focus.

## 8.4 Organizational Competencies

This section presents a discussion of the findings on the organizational competencies that allow Lean Six Sigma to be successfully deployed.

Insights into the organizational competencies have been presented in the literature review (refer section 2.8.2) and examples are given of some of the constructs within each broad category in Table 2.6. From the literature review, it is argued that the broad factors (Table 2.4) relating to organizational competencies are common across initiatives such as TQM and Lean Six Sigma (refer section 2.9.3). These factors are also common for manufacturing or service organizations (refer section 2.7.5) and are also common for large organizations and SME's (refer section 2.7.4). The key finding is that the constructs may vary according to whether the organization is large or an SME or a manufacturer or a service provider. For example, good data is critical to success but for service, the construct could be having a KPI and for a manufacturer it could be linking KPI's across the business.

It is clear that more recent journal articles have found similar constructs as critical factors when applying to their research data. Nevertheless, every construct seems to fit into one (possibly two) of the broad factor categories in Table 2.4.

In particular, Naslund (2013) suggests that the critical success factors are similar for all the change methods. Furthermore, the critical success factors seem to be relatively constant over time. Another important finding is that the critical success factor tends to relate more to how an organization approaches the change effort versus change method specific factors. The issues of management support and organizational culture are often emphasized as especially critical. The paper highlights and discusses three additional important critical success factors: strategic alignment, project management, and training. This is once again consistent with the broad categories of organizational competencies shown in Table 2.4.

In fieldwork phase 1, organizational competencies are developed further (refer Table 4.4 and section 4.9.4). Examples are given for each case organization.

In fieldwork phase 2, similar organizational competencies used by Powell (1995) for TQM are used to test the significance of the impact on performance measures (refer Table 5.2). Although these competencies are unique to a Hospital, there is consistency of application of the broad factors presented in Table 2.4. For the Hospital, tacit imperfectly imitable factors like "Open communication" and "Closer relationships with customers (or patients) and suppliers (or medical support staff)" contribute to the successful performance of an organization. This is consistent with the research of Naslund (2013) who establishes that the critical success factor tends to relate more to how an organization approaches the change effort versus change method specific factors.

In particular, fieldwork phase 2 describes which organizational competencies need further support by the Executive of the Hospital and provides competencies that are significantly related to Hospital performance. This provides insight into the order of importance of which competencies need to the supported first.

In fieldwork phase 4, using the same broad factors, a set of constructs for these broad factors is tested for significance for support by the organization. Three competencies that are supported well by the organization are Leadership, Continuous improvement and Line management drive (that is leadership down the line at the supervisor and team leader levels). The latter comment about line management drive supports the comments of Keeley *et al* (2012) that the core competencies and drive behind the Lean Six Sigma deployment program (Black Belts and Master Black Belts) are re-integrated into the line functions of the organization.

There are a number of competencies that do not appear to be supported by the organizations in the National survey. Variables that are not well supported are:

- Zero defects mentality
- Embedding the program in the Quality Management System
- Rewards for team based improvements
- Building on previous initiatives like TQM, BPR
- Structured approach to Black belt selection.

All these competencies appear to be contrary to the suggested competencies noted by various authors listed in Table 2.5 in Chapter 2, section 2.8.2.

In fieldwork phase 4, the organizational competencies noted by the respondents at the end of the National survey (refer section 7.5.7) support and expand (by way of further examples), the literature review in section

2.9.2, support the broad factors in Table 2.4 and the specific constructs in Table 7.2. Manually extracting the key points made by the respondents, that support and expand the specific organizational competencies using the broad factor categories, the following is noted to represent organizational competencies that are critical to success of the deployment of Lean Six Sigma.

Leadership must include the sustained support of the CEO and instill a culture of a "can do" attitude and there must be a high level of consistent and visible sponsorship. Leaders must understand strategy from the customer's viewpoint and how well organizational processes are aligned in order to deliver the desired customer experience.

Culturally, the organization as a whole needs to be totally committed to improvement in outcomes that influence customer experience and continuous improvement must be an embedded mindset. This is about staying the course until such time as it becomes part of the organization's language that is fully mature.

From a training perspective, the development of leadership as a skill across the entire organization is important as is good mentoring of team leaders and business leaders. Developing capability to run projects in line with the clearly articulated strategy of how improvement will fit within the strategic tool-set is important. Activity-based training (supporting just-in-time training) where each trainee should be assigned a project prior to training and then applying the DMAIC tools immediately to their project is important. Soft-skills training on how groups and people function in organizations that is being able to communicate effectively, lead and inspire teams are important and finally the choice of champions and project sponsors is important.

From a project management perspective, operations excellence project selection should be linked to overall business objectives and prioritized. Projects must drive the improvements through the business planning process and there needs to be adequate resources for teams. There must be the right level of modeling of the effect of variation to ensure that the benefits will translate to the bottom-line and deliver organization metrics. Finally many small successes will build engagement and team competencies better than fewer larger scale projects.

From a data and measurement perspective, it is important to ensure an understanding of the critical core business metrics and drivers and for the organization to demand that data backs up a strong opinion.

## 8.5 Personal Competencies

This section presents a discussion of the findings relating the personal competencies of the deployment leader and the project leaders in a Lean Six Sigma deployment.

In the literature review, it is noted that both the competency of the program facilitators and the project leaders is important in the impact on organizational success and comprise both technical and interpersonal competencies. In particular, interpersonal (or tacit) competencies are common between facilitators and project leaders.

### 8.5.1 Black Belt Competencies

In the literature review and fieldwork phase 3, Black Belts are shown to have a number of competencies. Examples of these include:

- A strong statistical knowledge and demonstration of competent application of advanced statistical tools and making use of the information gained to address the business problem
- Holding minimum standards of leadership, project management, and coaching and benefits delivery
- Ability to act as senior coaches, often leading larger programs of work with more junior coaches managing individual project streams
- Ability to mentor Green Belts on the way to certification and contribute to the delivery of training

- Good influencing/people skills.

In particular, the competency or knowledge of the project leader or Black Belt will have an effect on the choice of tools and validation of data during each phase of DMAIC (Shri Ashok *et al.*, 2013).

In fieldwork phase 4, the developed competencies shown in Table 7.3 are tested for significance. Average Black Belt competence significantly impacts Program Maturity level and has a strong relationship with average Project Success. When Black Belt competencies are divided into technical and interpersonal competencies the relationship between Program Maturity level and average Project Success does not change. The finding that the competencies "Has a process orientation" and "Good cross-functional skills" is significantly related to average Project Success is encouraging since these competencies have been ranked at a level of "at least agree" by the respondents in fieldwork phase 4.

Also in fieldwork phase 4, on average, organizations across the sample are only committing 21% of their workforce of Black Belts to working at least 50% of their time on projects. The most common role of a Black Belt is a project leader with the next most common being a Coach. At the end of the National survey in fieldwork phase 4, some respondents commented that the competence and experience of project leaders has varied "from good at statistical analysis but poor at project management, change management and basic people and communications skills". Others suggested they did not need finance knowledge.

In fieldwork phase 4, average Black Belt competencies are not assessed as different by respondents working in different industry sectors which appears to be different to the work of Black and McGlashan (2006).

The above comments suggest that training and professional development of the Black Belts needs reviewing but it has been less than satisfactory compared to the Lean Six Sigma Body of Knowledge (ASQ, 2012).

### 8.5.2 Master Black Belt Competencies

In the literature review and fieldwork phase 3, Master Black Belts are shown to have a number of competencies including:

- Developing or refining the deployment strategy
- Delivering Black Belt training
- Helping others to learn how to deliver Green Belt training
- Undertaking certification of Green Belts & Black Belts
- Providing technical advice
- Reviewing project work particularly where the use of advanced tools is involved
- Ability to lead multiple projects using a variety of the tools available to them

In fieldwork phase 2, the deployment facilitators were less qualified in Lean Six Sigma in cases 1, 2, 5 and 6 than the respondents in fieldwork phase 4. However, they had many others skills, suggesting that specific Lean Six Sigma skills are not mandatory for a successful deployment. In particular, the interviewee in case 1 suggested that their focus was more on Lean and less on DMAIC since Six Sigma experts, based on his experience, were very technical and not good at change management.

In fieldwork phase 3, roles for Master Black Belts have been shown to be expanded to include:

- Leaders and ambassadors within the organization, coaching several Black Belts in a coordinated body of work
- Either accountability for a division of the organization or as a coach and/or support roles for a number of practicing Black Belt Project Leaders
- Have an administrative role as well as active practitioners.

In fieldwork phase 4, the developed competencies shown in Table 7.4 are tested for significance. Average Master Black Belt competence does not impact

Program Maturity level but has a significant positive impact on average Project Success. There is no effect when average Master Black Belt competencies are divided into technical and interpersonal competencies. A finding is that the competency “Are able to coach Black Belts in advanced statistics” is significantly related to Program Maturity but this competency has not been ranked as low by the respondents, implying there is a gap in advanced statistical knowledge of Master Black Belts and a possible reason for low maturity levels. It is surprising that average Master Black Belt competency is significantly related to average Project Success as Black Belts would normally manage projects.

In fieldwork phase 4, average competencies for Master Black Belts do not vary between industry sectors but there is an effect of how long they have been working in Lean Six Sigma in years. The latter point is conditioned on the size of the coefficient of determination ($R^2$ = 15%).

In fieldwork phase 4, the level of influence of a Master Black Belt is not significantly related to Program Maturity level and this seems to be inconsistent with practice and from some of the respondent comments. However, the level of influence is significantly related to average Project Success at the 5% level implying that Master Black Belts can influence projects and they may step into the position of project leader sometimes. Some respondents noted that they had little influence in the deployment of Lean Six Sigma but the average influence level was 3.8 out of 5 indicating mostly that they did have high influence.

## 8.6 Relationship between TQM and Lean Six Sigma

This section presents a discussion of the findings relating to the differences and similarities between TQM and Lean Six Sigma.

In the literature review, it is clear that some research suggests that Lean Six Sigma has been derived from TQM and the difference really is that the former is project-based, which must have a sound business case and a formal infrastructure with the creation of Master Black Belts, Black Belts, Champions and other levels. There has been no such structure and requirements in previous quality initiatives like TQM.

A key observation is that both TQM and Lean Six Sigma have been described as a philosophy of improvement involving leadership, culture, education, projects and data (Goeke and Offodile, 2005). Lean Six Sigma is suggested to have come about because of short-comings of Lean and Six Sigma separately but there is some contradiction with its similarities and differences with TQM.

Drivers and success measures for all improvement initiatives like TQM do not seem to be significantly different. However, Six Sigma and TQM differ because of the excitement generated by Six Sigma when it was first launched, the financial benefits generated through projects and the training structure of the "Belts".

However, there are overlapping tools used for both TQM and Lean Six Sigma. Critical factors for success for TQM can be divided in five broad categories as well and examples within each category do not differ significantly with Lean Six Sigma.

It can be argued that there are a number of common elements in any quality improvement initiative that are necessary for the success of the program in the long-term. This is supported in the work by a number of authors who have demonstrated that there are similar practices and success factors between Lean Six Sigma, Six Sigma, Lean and TQM (Andersson *et al.*, 2006; Bendell, 2006; Cheng, 2009; Näslund, 2008; Talib and Rahman, 2010; Tsang and Antony, 2001; Zu *et al.*, 2010).

In particular, Naslund (2013) suggests that the critical success factors are similar for all the change methods. Furthermore, the critical success factors seem to be relatively constant over time. Using the research evidence, examples of these factors are summarized in Table 2.10 and are consistent with the examples of the broad factor categories for Lean Six Sigma presented in Table 2.5. It is important to note that the examples in Table 2.5 and Table

2.10 may overlap between each broad factor depending on the interpretation of the statement.

It is concluded in fieldwork phase 4 that the average organizational competency level is related to Lean Six Sigma program maturity and similar competencies, based on TQM (Powell, 1995) as described in fieldwork phase 2, are critical to success of the performance of a Hospital.

## 8.7 Lean Six Sigma Deployment Sustainability

Using the information and knowledge gained from the literature review and the insights obtained in fieldwork phases 1 to 3, a model and factor constructs for the sustainable deployment of Lean Six Sigma has been developed and tested in fieldwork phase 4.

This model combines Project Success and Program Maturity as a response (outcome) against a number of explanatory variables including the competency of an organization, the competency of the project leaders (Black Belts), and the competency and level of influence of the Program facilitator (Master Black Belt).

In fieldwork phase 1, there are a number of challenges arising to sustained deployment of Lean Six Sigma. These include the need to keep trained Lean Six Sigma experts from leaving to join a competitor or another industry, maintaining competence of “Belts”, training experts as trainers in advanced statistics, involving suppliers in the improvement programs, getting buy-in from all divisions of a large business, maintaining the use of DMAIC methodology, maintaining a culture willing to make significant changes and finally the need to always ensure that the organizations maintain their strategic involvement with Lean Six Sigma. This extends the previous literature on challenges to Lean Six Sigma (Kornfeld and Kara, 2013).

In fieldwork phase 2, a number of the organizational competencies for the Hospital were shown to be related to performance. Many of these align with the organizational competencies for Lean Six Sigma shown in Table 7.2.

From fieldwork phase 4, it appears that the competencies of Black Belts and Master Black Belts impact average Project Success more than Program Maturity level. Organizational competencies impact on Program Maturity level and less on average Project Success. For example, when average organizational competencies are well supported, then there is a high probability of the Lean Six Sigma program being mature (refer Figure 7.20).

There is a positive relationship between Program Maturity level and average Project Success and this is consistent with the idea that the success of many projects will influence a project team member's cognitive processes and together with other team members will enhance a quality improvement setting or culture (Choo, Linderman and Schroeder, 2007).

Program Maturity level is significantly and positively related to the number of years that an organization has been active in the program. This implies there is a basic level of maturity in most companies in terms of continuous improvement and that this maturity increases as the deployment of a Lean Six Sigma program becomes more active.

From the qualitative comments made in the National survey in fieldwork phase 4, many Lean Six Sigma deployments are in their early stages of maturity and this varies across industry sectors, but manufacturing organizations are more mature. Maturity in the service sector is less which appears to be due to poor process definition as a result of the lack of availability of data (Patton, 2005), although this was not highlighted as an issue in fieldwork phase 4.

Engagement and awareness seem to also diminish towards operational roles in the service sector. In the literature review, engagement and leadership down the line is critical (Byrne, 2003) and was highlighted as important in case 1 in fieldwork phase 1. This extends the results of the literature review on Lean Six Sigma (Duarte, 2011).

Larger and more strategic improvements are not gaining the traction they should with an absence of clear customer focus and strategic deployment. For some organizations in the early stages of deployment, engagement is building at executive level with the intent of becoming mature. This expands the articles in the literature review on critical success factors for Lean Six Sigma to suggest that executive engagement is critical from day one of the deployment.

The comments on maturity noted by the respondents at the end of the National survey (refer section 7.5.8.4) provide further insight into the concept of maturity. One point made by the respondents addresses the low levels of maturity of Lean Six Sigma being due to poor leadership, poor strategy, inadequate recognition systems, poor HR employee engagement practices, inability to managing continual changes, lack of leadership at operational roles and because many LSS experts have moved on. This is consistent with the work of Timans et al. (2012). This lack of maturity presents challenges to organizations aiming for high levels of maturity and as such it is critical for organizations to maintain support for all the competencies noted in Table 7.2. This provides practical insight into the concept of maturity.

Another point is that manufacturing deployments are more mature than service due to poor process standardization. Connected to this is the point developed by Naslund (2013) that the awareness of a critical success factor, in combination with an awareness of similarities between the improvement methods, can potentially guide organizations in implementations of existing change efforts towards maturity and also prepare them for the next widely popular change method – if and when it arrives.

Finally, in the National survey in fieldwork phase 4, it is suggested that it can be very difficult for business leaders to remain focused on the improvement projects and it can be difficult to mentor, monitor and implement process change, implying high levels of maturity are difficult to reach. This suggests the program facilitator or Master Black Belt and the project leaders or Black Belts' need have well rounded competencies across change management and project management. This extends the competency argument for these Lean Six Sigma experts.

## 8.8 Summary of chapter 8

This chapter presents a discussion of the research questions 1 to 5 in sections 8.2 to 8.6 respectively linking the information gathered in the literature review and the data and knowledge gained from fieldwork phases 1 to 4. In section 8.7, a discussion of the model for the sustainable deployment of Lean Six Sigma is presented.

# 9. Chapter Nine: Conclusions and Recommendations

## 9.1 Introduction

In this research study, a comprehensive literature review and four fieldwork phases have been completed. Five research questions have been developed from the literature review and examined in the fieldwork phases 1 to 4. Fieldwork phase 1 involved face-to-face interviews using semi-structured questions of senior managers employed as Lean Six Sigma facilitators in organizations in Australia. Fieldwork phase 2 involved an in-depth study using a questionnaire of 17 managers in a Hospital in Australia. Fieldwork phase 3 involved an open questionnaire completed by two Master Black Belts in Lean Six Sigma. A model for the sustainable deployment of Lean Six Sigma was developed from insights gained from the literature review and fieldwork phases 1, 2 and 3. Fieldwork phase 4 involved testing the model using a National survey of Australian organizations that have deployed Lean Six Sigma and where the respondents were typically Operations Excellence executives mainly with qualifications at Master Black Belt level in Lean Six Sigma.

This chapter is presented in five sections. This first section summarizes the key findings for each research question (RQ). The second section discusses the developed model for Lean Six Sigma sustainable deployment. The third section presents the implications to theory and practice of Lean Six Sigma. The fourth section makes recommendations on future research on Lean Six Sigma and finally the fifth section presents a summary of the limitations of the study.

## 9.2 Key Findings

### 9.2.1 RQ 1: What are the key drivers and success measures of a Lean Six Sigma deployment?

Organizations are deploying Lean Six Sigma to drive success in both organizational level and operational level metrics (Caulcutt, 2001; O'Rourke, 2005; Pyzdek, 2003a; Shah *et al.*, 2008). There are many examples of what drives Lean Six Sigma and how it can be measured for success but clearly these drivers and success measures are either at an organization or operations level.

There are some differences in drivers for large organizations and SME's and those in Healthcare - refer to cases 1, 5 and 7 in fieldwork phase 1. There are examples of both successes and failures of Lean Six Sigma due to the choice of success measure (Goh *et al.*, 2003; Lee and Choi, 2006; Pyzdek, 2004). Clearly, for organizations to achieve success at the organizational level they must drive towards ongoing project success at an operational level to ensure there is a mature deployment of Lean Six Sigma, ideally at a level in which Lean Six Sigma is a part of their DNA (Duarte, 2011; Moosa and Sajid, 2010; Olson, 2010; Raje, 2009). This is supported by the qualitative comments of respondents to the survey in section 7.5.8.4 in fieldwork phase 4.

Australian businesses have deployed previous quality initiatives like TQM and quality circles without success mainly because improvements were not able to be financially measured - refer cases 2, 4 and 7 in fieldwork phases 1.

Success of a Lean Six Sigma deployment needs to be measured by a combination of operational level metrics from projects and a level of maturity of the deployment - refer results in section 7.5.8 and focus group summary in section 7.6 in fieldwork phase 4.

### 9.2.2 RQ 2: What are the characteristics of the way Lean Six Sigma has been deployed and is it affected by organizational size?

The scope of the deployment of Lean Six Sigma can vary widely and may incorporate principles and practices from all quality methodologies (Byrne, 2003; Challener, 2001; Knowles *et al.*, 2004; Motwani *et al.*, 2004; Revere and Black, 2003; Yacovone, 2007). There are many applications of Lean Six Sigma in different industry sectors, including manufacturing, health, banking and government/public sector (Zhu and Hassan, 2012) but Lean Six Sigma does not have a universally common meaning or implementation procedure (Gershon and Rajashekharaiah, 2011).

The type of Lean Six Sigma model used can vary from the use of simple tools within the DMAIC phases to more complex tools (Mader, 2008). This is demonstrated in Table 4.3 in fieldwork phase 1 and figure 7.2 in fieldwork phase 4. Deployments in large organizations are more likely to use complex tools (usually advanced statistical tools) within the DMAIC cycle since trained "Black Belts" lead the projects - refer cases 3 and 4 in fieldwork phase 1. Service organizations in the Health sector appear to have used the deployment in manufacturing as a benchmark in their own Lean Six Sigma deployment (Antony, 2008b). This is supported with cases 3, 6 and 7 in fieldwork phase 1.

SME's tend not to train "Belts" since the cost of training of the practitioners is restrictive (Davis, 2003). This is demonstrated in cases 1, 2 and 5 in fieldwork phase 1. In the service sector, there are not many Black Belts and Master Black Belts working full-time (Antony, 2008b). However, this is inconsistent with cases 3 and 6 in fieldwork phase 1. The lack of data in the service sector restricts the success of projects (Patton, 2005). This is inconsistent with the evidence presented for cases 3 and 6 in fieldwork phase 1.

Program Maturity varies across organization sectors, organization sizes and is positively related to the number of years the organization is active (above 5 years) in Lean Six Sigma - refer to figures 7.7, 7.9 and 7.11 in fieldwork phase 4. Lean is commonly used before Six Sigma to get quick wins (Jorgensen, 2004) especially in SMEs (Antony, 2008b) and in service organizations (Prasanna and Sekar, 2013). This is consistent with the qualitative comments of respondents in section 7.5.4 in fieldwork phase 4.

### 9.2.3 RQ 3: What are the competencies of an organization that result in the successful deployment of Lean Six Sigma?

Leadership is a mandatory requirement for successful deployment of Lean Six Sigma (Banuelas *et al.*, 2006; Antony, 2007; London, 2002; Malik and Blumenfeld, 2012; Ray and Das, 2010). Also refer to Table 2.6. If organizations support a number of competencies noted in Figure 7.6 that are below the level of "Agree" (scale 1 or less) then it would appear that Lean Six Sigma programs will be mature and successful. For example, many organizations find it easy to support Leadership, Continuous improvement and Line management drive (that is support down-the-line for team leaders and supervisors) but do not find it easy to support a structured approach to Black Belt selection – refer to figure 7.6 in fieldwork phase 4.

Adopting some of basic TQM principles, for example, "Zero defects" and "rewards for team-based improvements", are useful but these are not well supported in large and medium-sized organizations - refer to Table 5.4 in fieldwork phase 2 and figure 7.6 in fieldwork phase 4.

Incorporating Lean Six Sigma into Business management, for example including as part of ISO/TS management system makes sense (Zu *et al.*, 2010) but this is not well supported - refer to cases 1, 2, 4 and 5 in fieldwork phase 1 and figure 7.6 in fieldwork phase 4. Recognition systems assist successful deployment (Jeyaraman and Teo, 2010) but this is not well supported by organizations - refer to figure 7.6 in fieldwork phase 4.

Attrition of Lean Six Sigma experts is a challenge to some organizations – refer Table 4.6 in fieldwork phase 1. It is important to minimize the gap in the organizational structure due to the attrition of Lean Six Sigma experts and this may impede the maturity of a Lean Six Sigma deployment - refer to qualitative comments of respondents in section 7.5.8.4 in fieldwork phase 4.

Awareness of Lean Six Sigma across organizations is critical – refer to case 7 in fieldwork phase 1 and the case in fieldwork phase 2**.** Adopting organization-wide communication standards, methods and protocols and communication skills training will help project teams communicate and sell their ideas, plans and solutions internally and will substantially increase a project's likelihood of success – refer case 3 in fieldwork phase 1.

### 9.2.4 RQ 4: What are the personal competencies of the deployment leader and project leaders for a Lean Six Sigma deployment to be successful?

Master Black Belt competencies impact on average Project Success but it has little effect on Program Maturity level - refer figure 7.18 in fieldwork phase 4.

The influence level of Master Black Belt impacts average Project Success but has little effect on Program Maturity level - refer to section 7.5.8.2 in fieldwork phase 4.

Master Black Belts tend to think their ability to coach Black belts in advanced statistics is not high - refer to figure 7.4 in fieldwork phase 4. Master Black Belts view their typical Black Belt with low competencies in statistics as well, indicating a common gap in statistical training - refer figure 7.5 in fieldwork phase 4. Average Master Black Belt competencies do not vary between industry sectors but there is an effect of the number of years they have been working in Lean Six Sigma – refer to section 7.5.5 in fieldwork phase 4.

Interpersonal (or tacit) skills for both the program facilitator and the project leaders are critical and are similar – refer figures 7.4 and 7.5 in fieldwork phase 4 and Tables 6.1 and 6.2 in fieldwork phase 3. Average Black Belt competencies impact both on average Project Success and Program Maturity level – refer figure 7.17 and section 7.5.8.2 in fieldwork phase 4. Average Black Belt competencies are not assessed as different between industry sectors – refer Table 7.7 in fieldwork phase 4.

### 9.2.5 RQ 5: What success factors are common between Lean Six Sigma and previous quality improvement initiatives like TQM?

As philosophies, both TQM and Lean Six Sigma are similar but they differ significantly in implementation procedure (Antony, 2004b; Stamatis, 2003; Thawani, 2004). TQM have been shown to be either successful (Ahmad and Yusof, 2010; Dinh Thai *et al.*, 2010; Hongyi and Yangyang, 2010; Santora, 2009; Talib and Rahman, 2010; Tsuang *et al.*, 2009) and there have been some failures (Brown, 1994; Cao *et al.*, 2000; Eskildson, 1994; Harari, 1997). Drivers and success measures (both organizational and operational) for all quality improvement initiatives have not changed since the concepts of continuous improvement were first proposed (Dolich *et al.*, 1994).

Clearly, there are overlapping tools and methodologies between Lean Six Sigma and TQM (Zu *et al.*, 2010) and Lean Six Sigma deployments involve significant training in "Belts" but TQM does not involve improvement projects (Antony, 2009). The important point that is developed in this study is that the broad factors critical to the success (that is, organizational competencies) are common across initiatives like Lean Six Sigma and TQM - refer to Tables 2.6 and 2.11 in literature review and to appendix 2 in fieldwork phase 2. Generalizing, it can be argued that organizational competencies associated with all continuous improvement programs are common. It is further argued in this study that a lack of support for these organizational competencies provide a possible cause to the failure of any of the improvement initiatives mentioned - refer to section 7.5.8.2 in fieldwork phase 4.

## 9.3 Implications for Lean Six Sigma theory and practice

The study focuses on answering five research questions developed from a review of the relevant literature and developing a model of sustainable deployment of Lean Six Sigma.

The research framework has involved a comprehensive literature review and fieldwork using both qualitative and quantitative analysis of data obtained from a number of organizations in Australia. The fieldwork has included face-to-face interviews using semi-structured questions with seven cases in manufacturing and service (both SMEs and large organizations); an in-depth analysis of one of these seven cases in Healthcare; results of an open questionnaire of two senior experienced Master Black Belts; and finally data obtained from a sample of respondents who have experience as a Lean Six Sigma practitioner, trainer or consultant and are involved with organizations from different industry sectors in Australia that have deployed Lean Six Sigma.

This is the first empirical study of its kind on Lean Six Sigma in the Australian context and the insights gained from the fieldwork provides practitioners working in the field of Lean Six Sigma with key strategies for a sustainable deployment.

In particular, the Lean Six Sigma sustainable deployment model developed and tested in this research represents a theoretical contribution - see Figure 7.2. This model describes a relationship between two response variables (Program Maturity and Project Success) and a number of explanatory variables (Organizational Competence, Personal competence of the Black Belts and Personal competence and influence level of the Master Black Belts).

From a practical viewpoint, the model identifies the gaps in both organizational competencies for Australian business and personal competencies of the Lean Six Sigma experts.

The research also provides practitioners working in the field of Lean Six Sigma, a model that will support the long-term sustainability of Lean Six Sigma measured by Project Success and Program Maturity. It achieves this by suggesting that an organization must attain a level of competence in key areas including leadership, culture, training, project management and data measurement and analysis and the project leaders and deployment facilitators must also attain a level of competence both in technical and interpersonal skills and further deployment facilitators must have relatively high levels of influence.

This model may only apply to organizations that have a Master Black Belt or Black Belt facilitating the program. For an SME for example, where perhaps a Green Belt facilitates the program, there could be some slight differences relating to levels of influence and competencies. The model should apply to both manufacturers and service organizations and the public sector.

In particular, insights for practitioners include:

- Applying simple tools in project improvements using DMAIC are common
- Getting the organization to support a competency-based deployment program makes sense (as shown in Table 7.2)
- Ensuring Black Belts have soft skills for effective project delivery

- Ensuring Master Black Belts have coaching and mentoring skills in advanced statistics and have an influence on the overall deployment

This competency based perspective of organizations and the Lean Six Sigma experts (Master Black Belts and Black Belts) is an extension to the current theory that only considers training and education of experts in the field of Lean Six Sigma.

This model can be used in future research to investigate the effect of performance of Lean Six Sigma and other constructs applicable to the explanatory variables. In particular, the model could also be extended to relate these explanatory variables with organizational level metrics as demonstrated by Figure 9.1. This extended model would allow organizations to understand the key inputs that drive organizational level metrics like profitability, customer satisfaction, market share, employee engagement and a continuous improvement culture. It would essentially be a combining of Figure 7.2 and Figure 2.1.

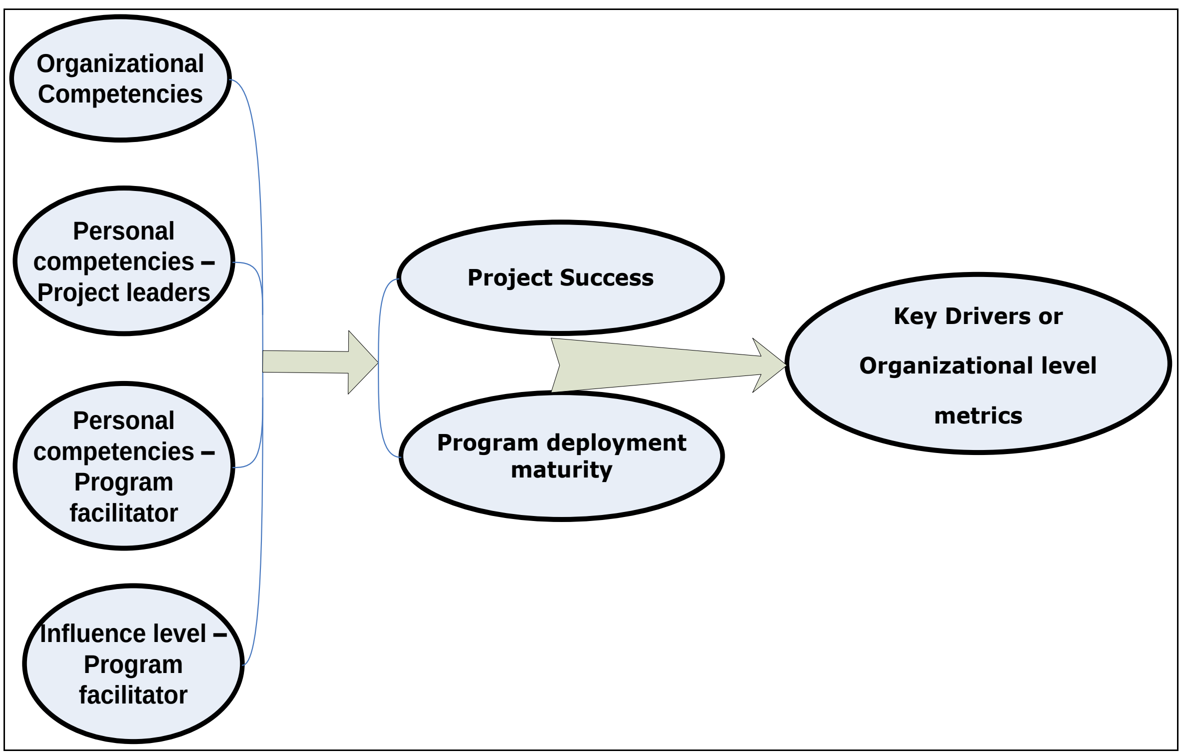


Figure 9.1: Linkage between Organizational metrics and Key explanatory Variables

The introduction of the concept of personal competence enhances the notion of training and education of Lean Six Sigma experts and represents a theoretical contribution to the research into Lean Six Sigma.

A further theoretical contribution is the combination of the concept of maturity and project success as a more relevant measure of success of Lean Six Sigma. Maturity was highlighted in the literature review but its combination makes more sense based on fieldwork phase 4.

The study develops the idea that there are five broad factors for organizational competencies but there are varied constructs (items) that are applicable to any improvement initiative like Lean Six Sigma and TQM. When embarking on a continuous improvement strategy like Lean Six Sigma, it is important for organizations and practitioners to identify and review these five factors and their constructs to obtain insight into which competencies need to be supported and which are part of the way the organization currently does business. This review of competencies appears to be more important than the choice of improvement methodology, whether it be TQM or Lean Six Sigma.

Specifically, before deploying Lean Six Sigma, organizations need to:

- Evaluate the level of organizational competencies (according to a list of competencies as shown in Table 7.2) are sufficient to ensure that a continuous improvement culture has been established
- Evaluate the levels of competencies of the Black Belts and Master Black Belts as shown in Tables 7.3 and 7.4 respectively are sufficient to ensure projects are successful and deployment is mature
- Evaluate the influence of the deployment facilitator as shown in Table 7.5 to ensure the program has the required presence on the leadership team
- Adopt Lean first for quick wins and then deploy DMAIC projects using all Lean, statistical and quality tools
- Adopt simple statistical models throughout the DMAIC phases to ensure better up-take and less complexity in projects to allow quick wins

- Investigate the availability of Federal Government funding to assist in the cost of training staff to Yellow, Green and Black Belt levels to support the widespread awareness of Lean Six Sigma especially for SMEs

Gaps in the technical and interpersonal competencies of the Black Belts provide an important basis for the design of a Black Belt training program and this should give Lean Six Sigma training organizations further insights into the focus of their training program.

## 9.4 Limitations of Study

In the qualitative fieldwork phase 1, the results are limited to data collected from the seven case organizations in which a cross-case analysis is made but generalizations cannot be made.

In the quantitative fieldwork phase 2, the results are limited to data collected from one Healthcare organization in which only 17 participants were asked to respond to the questionnaire. These results may not be valid given the low number of respondents (Nunnally and Peteraf, 1978).

In the qualitative fieldwork phase 3, the results were only obtained from two experts in Lean Six Sigma and these experts may not be representative of the voice of Master Black Belts.

In the quantitative fieldwork phase 4, data collected from 95 organizations deploying Lean Six Sigma represented about only 63% of the total of about 150. For some industry sectors, data was limited. Further, this fieldwork only obtained responses from deployment facilitators, that is, mostly Master Black Belts. Finally, the Australian experience is examined and this may not apply to other countries.

This study also recognises the following limitations:

- The analysis undertaken is based on the responses and perceptions of the interviewees at a particular point in time
- Generalizability of the results of this study to other contexts should be done with caution particularly across industry sectors.

Further detail regarding the limitations of this study is presented in Chapter 3, section 3.4.

## 9.5 Recommendations for Future Research

This research project has only carried out a preliminary comparison between manufacturing and service organizations. A more detailed research into a comparison of the deployment of Lean Six Sigma in manufacturing and service organizations could be a topic of further research in order to document the differences in deployment strategies, challenges and benefits and organizational competencies.

In fieldwork phase 4, one Master Black Belt was asked to complete the survey on behalf of the organization and to assess a typical Black Belt. This could be extended to include an in-depth case study of a multinational organization that employs a large number of Lean Six Sigma experts in order to assess for example, the level of standardization of tools used in the DMAIC methodology, differences in training and the differences in roles and personal competencies.

An evaluation of the training of, and competency criteria for Lean Six Sigma experts, both program facilitators (Master Black Belts) and project leaders (Black Belts), both from a technical and interpersonal perspective could be a topic of further research. Also, studying the effect of training type (online or otherwise), number of days training and industry sectors would be useful.

In particular, it would be useful to compare the competencies that are derived using the model developed in this research with the competencies noted by the expanded Body of Knowledge of the American Society for Quality (ASQ, 2012) and other international standards, for example the International Six Sigma standard which incorporates Lean (ISO13053, 2011). This would provide a consistent set of competencies useful for a standardized training, educational and professional development for Lean Six Sigma practitioners.

This study briefly commented on the link between organizational level metrics and operational level metrics through project success and a mature program. As such, because the choice of performance indicators (organizational or operational) can influence the assessment of the success or otherwise of Lean Six Sigma, it is important to further research and examine what constitutes successful performance of Lean Six Sigma.

## 9.6 Summary of chapter 9

This chapter summarizes the key findings for each research question, discusses the developed model for Lean Six Sigma successful deployment, presents the implications to theory and practice of Lean Six Sigma, makes recommendations on future research on Lean Six Sigma and presents a summary of the limitations of the study.

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# Appendices

## A1: Semi-Structured questionnaire for face-to-face Interviews

1. What triggered the need to implement Lean Sigma?
2. What is the breadth of the company's lean six sigma program? Is it viewed as a company-wide strategy encompassing a framework of best practice and management principles or has it been implemented for particular critical-to-customer projects? Comment.
3. What external and internal forces have driven six sigma's progress since implementation?
4. What are the strengths of the implementation approach? Are there any weaknesses / opportunities of your implementation approach?
5. What has been the strategy to ensure employee commitment to the sustainability of Lean Sigma? Has training been used to foster employee engagement?
6. Comment on any inconsistencies in the application of Lean Sigma across the organization. To what would you attribute this inconsistency? Do you feel that the inconsistency is partly due to the black and/or green belt's level of operational or business knowledge and their level of academic training? Please comment.
7. Have there been any directly measurable/tangible benefits achieved? E.g. return on investment, share price, customer satisfaction, employee satisfaction and other measures of performance.
8. Describe the degree to which the management is able to empower the workforce
9. What has been your perception of the cultural / intangible impacts of Six Sigma in your company to date?
10. What is your view on the viability of Lean Sigma as a competitive strategy for your organization? Do you think the role of Lean Sigma is a future competitive strategy for Australian businesses generally?

11. What are the factors which contributed to or hindered success in a Lean Sigma implementation? Have the intangible factors like project team synergies and employee engagement had significant impact compared to the actual Lean Sigma methodology? If so please comment.
12. Has your organization implemented TQM in the past and if so was it successful and why? Why did your company choose to implement Six Sigma after TQM? How different has Six Sigma been from TQM and comment on whether Six Sigma has had more impact.
13. How has your lean sigma training been performed? Either by external consultants; by key customers?; by internal means?; by US affiliates?; by other means
14. Has the training been successful? That is has it generated participants engagement in Lean Six Sigma? Explain the activity. What are the competency measures for the participants?
15. Describe any other aspect of your Lean Six Sigma program that you see as relevant to future improvements of the program e.g. impacts on performance, the company culture, employees, suppliers, customers and senior management

## A2: Hospital Questionnaire 1

| Hospital Quality Survey | | Expected rank * | Actual rank ** |
|---|---|---|---|
| **Factor** | **Questions** | | |
| **Executive Commitment** | • The executive of the hospital is committed fully to the performance improvements?<br>• The top executives are actively championing the performance initiatives?<br>• Executives are actively communicating the performance commitments to all staff? | | |
| **Adopting the philosophy** | • The performance principles are included in the hospitals mission?<br>• There is a need for high quality and health & safety standards? | | |
| **Benchmarking** | • An active competitive benchmarking program is necessary?<br>• Researching best practices of other hospitals is critical?<br>• Visiting other hospitals to investigate best practices first hand is necessary for all staff in an awareness program? | | |
| **Training** | • Training in Quality principles is important?<br>• Training in problem solving skills is important?<br>• Training in teamwork facilitation, structure and action is important?<br>• General awareness training in performance improvement methodologies is important? | | |
| **Closer customer relationships** | • There is an increasing need for direct personal contacts with patients?<br>• Actively seeking patient inputs via surveys to determine the quality requirements is necessary?<br>• There is a need for measuring patient satisfaction and tracking? | | |
| **Closer supplier relationships** | • Working more closely with providers of specialist and other services is paramount?<br>• Providers of specialist services need to meet stricter quality specifications?<br>• Providers of specialist services need to adopt a similar performance improvement program<br>• Providers of specialist services need to be tracked for performance and may need to be audited in some cases?<br>• Providers of non-specialist services need to be trained in the hospitals systems?<br>• Providers of specialist services need to be involved in hospital project teams, for example in Product development<br>• Cost of in-coming quality needs to be measured and displayed at the hospital? | | |

| | | | |
|---|---|---|---|
| **Open organization** | • An open, trusting organizational culture is necessary for the hospital?<br>• Frequent use of cross-departmental and empowered teams is important? | | |
| **Employee empowerment, engagement and morale** | • An active employee suggestion system is necessary?<br>• Employee autonomy in decision-making is important?<br>• Increased employee interaction with patients and service providers is necessary?<br>• A suitable recognition and rewards process is necessary?<br>• Conducting an employee survey to establish satisfaction levels and culture could be useful? | | |
| **Flexible operations** | • A Just-in-Time inventory system would be helpful?<br>• Analyzing processes using statistical process control methods for capability, for example defect rates, is necessary?<br>• Design of Experiments (DOE) to study repeatability and reproducibility of test methods could be informative? | | |
| **Process improvement** | • Reducing operations process cycle time is critical?<br>• Improving cycle times for all services is important?<br>• A program to reduce overall product or service delivery times is critical?<br>• A program to reduce paperwork is necessary?<br>• A program to find wasted time and costs in all processes could be helpful? | | |
| **Measurement** | • Measuring performance in all areas is necessary?<br>• Using charts and graphs to measure and monitor Quality is helpful?<br>• Employee training in statistical methods for measuring Quality is necessary? | | |
| **Organizational structures** | • A senior management quality council is necessary as well the hospital executive?<br>• Owners of quality should at department level?<br>• Nominating internal quality department champions could be useful?<br>• External quality consultants could be used to facilitate improvements? | | |
| **Zero defects mentality** | • An announced goal of zero defects is important?<br>• A program to continuously reduce defects is critical?<br>• A plan to reduce rework is important? | | |

| | | | |
|---|---|---|---|
| **Teams** | • The following team's approaches are important?<br>o Workforce improvement teams<br>o Natural work group teams<br>o Cross functional teams<br>o Vertical teams<br>o Work cell teams<br>o Self-managed teams<br>o Project oriented teams<br>o Management teams | | |
| **Planning and values** | • Written quality values and/or mission statements are important?<br>• Aligning hospitals goals with staff development and actions is critical? | | |
| **Audits** | • Quality management audits are necessary in certain areas of the hospital?<br>• Hospital certifying to international standards gives a competitive edge? | | |
| **Problem solving tools** | • A standard problem solving process or root cause analysis is important in the hospital?<br>• Process flowcharting should be understood and used extensively?<br>• A standard continuous improvement methodology is important? | | |
| **Design and engineering** | • Access to outpatients is critical to the ultimate performance?<br>• Designing experiments to check hospital data is important?<br>• Quality function deployment is a useful technique? | | |
| **Production** | • Statistical Process Control, JIT, process cycle time reduction and change over times are critical in the hospitals management of patient's satisfaction?<br>• Activity based costing is important in administering patient's files?<br>• Work cells give flexibility to the hospital staff? | | |

**For column * enter a rank for your agreement with the item**
**Ranks are: 0 = not applicable; 1 = 100% disagreement; 2 = 75% disagreement; 3 = 50% agreement; 4 = 75% agreement; 5 = 100% agreement**

**For column ** enter a rank for the level of effectiveness in the Hospital**
**Ranks are: 0 = not applicable; 1 = 100% ineffective; 2 = 75% ineffective; 3 = 50% effective; 4 = 75% effective; 5 = 100% effective**

## A3: Hospital Questionnaire 2

| **Specific Performance measure** | **Actual Rank 1 to 5** |
|---|---|
| There is equitable access to emergency treatment | |
| There is timely access to emergency treatment | |
| There is accurate access to emergency treatment | |
| There is appropriate access to emergency treatment | |
| There is equitable access to outpatients clinics | |
| There is timely access to outpatients clinics | |
| There is accurate access to outpatients clinics | |
| There is appropriate access to outpatients clinics | |
| There is equitable access to the community | |
| There is timely access to the community | |
| There is accurate access to the community | |
| There is appropriate access to the community | |
| There is equitable discharge to the community | |
| There is timely discharge to the community | |
| There is accurate discharge to the community | |
| There is appropriate discharge to the community | |
| **General Quality Performance** | |
| Our quality program has reduced the length of time on surgical waiting lists | |
| Our quality program has reduced the length of time waiting in hospital for an appointment - ED or Outpatients | |
| Our quality program improvements has improved the patients perception of treatment and care | |
| We would have been better off without a quality program | |

## A4: National Survey of Lean Six Sigma deployment facilitators

Submit by email Print Form

MONASH University

# Lean Six Sigma Survey

## A Model for the successful deployment of Lean Six Sigma

Thank you for taking time to complete this questionnaire.

This questionnaire is directed towards the Master Black Belt in an organization or the person with an equivalent position. For example this person may be the Process Excellence Director, Quality Manager or Business Improvement Manager. The questionnaire can be completed by consultants or trainers that have previously held a permanent or a contract position equivalent at a Master Black Belt level. In this case please answer the questions about the position that you held previously and the organization that employed you.

This questionnaire asks you

1. about your company
2. certain competencies that you possess
3. competencies of a typical Black Belt (or the person with an equivalent position), who would normally lead improvement projects in your organization
4. the influence level that your role has in directing and leading change and
5. the competencies of your organization you are working with

The questionnaire should take no more than 15 minutes to complete. After you have completed it please send to Roger Hilton using the button at the top of this page (It will be directed to [redacted] and [redacted]).
If you wish to mail it please print a copy and send it to the address marked below.

All correspondence should be directed to:
Roger Hilton, [redacted]
Department of Management
Faculty of Business and Economics
Monash University
PO Box 197, Caulfield East Vic 3145

Should you have any complaints concerning this study, contact the Standing Committee on Ethics in Research Involving Humans on +61 3 9905 2052. You can ask to speak to the secretary or you could also write to the secretary at the following address: The Secretary, The Standing Committee on Ethics in Research on Humans, PO Box No 3A, Monash University, VICTORIA 3800; **Email:** SCERH@adm.monash.edu.au

## Section A: Demographic Information

Please provide the following information about yourself by ticking the appropriate response category.

1. What is your employment status?

☐ Employee ☐ Trainer/Consultant ☐ Other (Please specify) _______________

2. What is your highest Lean Six Sigma qualification?

☐ Master Black Belt ☐ Black Belt ☐ Green Belt

☐ Lean Practitioner Other (Please specify) _________________

3. What is your highest educational qualification?

☐ Doctorate ☐ Masters ☐ Bachelors Other (Please specify) _______________

4. Are you the deployment facilitator?

☐ Yes, across the business ☐ Yes, for only part of the business ☐ No

5. What level of influence does the role of deployment facilitator have in creating change?

| Very high Influence | High Influence | Average Influence | Low Influence | Very Low Influence |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

6. How long have you been working in Lean Six Sigma? ____________ years

7. If you are trained in Lean Six Sigma how much classroom training did you receive?
   a. For Master Black Belt ________ days
   b. For Black Belt ________ days
   c. For Green Belt ________ days
   d. Other Please specify _________ ________ days

8. What is the industry sector for your organization?

| Manufacturing | Finance & Insurance | Mining Services | Health & Community Services | Government | Other (Specify) _____________ |
|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

9. What is the size of you organization in terms of number of employees?

| < 50 | 50 < 250 | 250 < 500 | 500 < 1000 | > 1000 |
|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ |

## Section B: Lean Six Sigma Deployment Information

Please provide the following information about the improvement projects and how the program is deployed within your organization and, where necessary by ticking the appropriate response category.

10. How long has your organization been actively involved in Lean Six Sigma? ______________ years

11. How many improvement projects have you facilitated over the last 5 years? No. is ______________

12. Overall how successful is a typical project from the point of view of?

| | Not Measured | Not Successful | Very Low Success | Low Success | Average Success | High Success | Very High Success |
|---|---|---|---|---|---|---|---|
| Overall Quality | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Process efficiency | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Responsiveness | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Cost Reduction | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Project Schedule Adherence | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| Other Specify ______________ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

13. How would you classify the maturity of your deployment?

- ☐ The “Launch” is the starting point wherein an initial few visionaries in the organization launch Lean Six Sigma, training is initiated and projects begin
- ☐ The “Early Success” is where the initial projects are yielding results and early successes are being achieved
- ☐ The “Scale Replication” stage is where the early success has led to other parts of the organization buying into Lean Six Sigma and a broader launch of projects in underway

☐ The ""Institutionalization" is where projects are yielding broad based financial impact throughout many parts of the organization

☐ "Culture Transformation" is where Six Sigma is part of the organizational DNA, financial impact is sustained and the Six Sigma culture is pervasive – even beyond the Lean Six Sigma practitioners and beyond the organization boundaries

14. How would you classify the type of Lean Six Sigma deployment in your organization?

☐ Most projects following Define-Measure-Analyse-Improve-Control (DMAIC) using advanced Lean and Six Sigma statistical tools

☐ Most projects following DMAIC using simpler statistical tools with some lean tools

☐ Mostly projects use lean based tools with some simple quality tools

☐ Most project methodologies have been derived from previous improvement initiatives like Total Quality Management and Business Process Reengineering

☐ Other (Please specify) ________________________________________

15. What proportion of your staff is spending more than half of their time working as a Black Belt or similar role? ____________________ %

16. What role does the typical Black Belt play in your organization most of the time?

☐ Project Leader ☐ Analyst ☐ Trainer ☐ Coach

☐ Other (Please specify) ________________________________________

## Section C: Typical Black Belt Competencies

Please provide the following information about the Black belts in your organization by ticking the appropriate response category.

| **Statement – Your typical Black Belt….** | **Totally disagree** | **Disagree** | **Neutral** | **Agree** | **Totally agree** |
|---|---|---|---|---|---|
| C1. Is able to facilitate and lead teams | ☐ | ☐ | ☐ | ☐ | ☐ |
| C2. Is Results-driven | ☐ | ☐ | ☐ | ☐ | ☐ |
| C3. Has good mathematical & statistical skills | ☐ | ☐ | ☐ | ☐ | ☐ |
| C4. Is Data driven | ☐ | ☐ | ☐ | ☐ | ☐ |
| C5. Has strategic level knowledge | ☐ | ☐ | ☐ | ☐ | ☐ |
| C6. Has cross-functional skills | ☐ | ☐ | ☐ | ☐ | ☐ |

| | | | | | |
|---|---|---|---|---|---|
| C7. Has a process orientation | ☐ | ☐ | ☐ | ☐ | ☐ |
| C8. Has a finance orientation | ☐ | ☐ | ☐ | ☐ | ☐ |
| C9. Is an effective communicator | ☐ | ☐ | ☐ | ☐ | ☐ |
| C10. Has good change agent and influence skills | ☐ | ☐ | ☐ | ☐ | ☐ |
| C11. Is customer focused | ☐ | ☐ | ☐ | ☐ | ☐ |
| C12. Is able to facilitate learning in project teams | ☐ | ☐ | ☐ | ☐ | ☐ |
| C13. Is a positive thinker | ☐ | ☐ | ☐ | ☐ | ☐ |
| C14. Has logical thought, problem solving capability | ☐ | ☐ | ☐ | ☐ | ☐ |
| C15. Has a desire for high level positions | ☐ | ☐ | ☐ | ☐ | ☐ |
| C16. Is committed to continuous learning | ☐ | ☐ | ☐ | ☐ | ☐ |

## <u>Section D</u>: Your Competencies as a Master Black Belt

Please provide the following information about yourself as Master Black Belt for your organization by ticking the appropriate response category. ***If you are not the deployment facilitator, indicate your level of agreement based on knowledge of this person.***

| **Statement – You (or the deployment facilitator) ….** | **Totally disagree** | **Disagree** | **Neutral** | **Agree** | **Totally agree** |
|---|---|---|---|---|---|
| D1. Are able to develop implementation strategy | ☐ | ☐ | ☐ | ☐ | ☐ |
| D2. Are able to coach staff at all levels | ☐ | ☐ | ☐ | ☐ | ☐ |
| D3. Are able to coach Black Belts in advanced statistics | ☐ | ☐ | ☐ | ☐ | ☐ |
| D4. Are able to create training programs for the organization | ☐ | ☐ | ☐ | ☐ | ☐ |
| D5. Have an ability to obtain and allocate resources | ☐ | ☐ | ☐ | ☐ | ☐ |
| D6. Are able to coordinate multiple projects across the organization | ☐ | ☐ | ☐ | ☐ | ☐ |
| D7. Are influential at getting buy-in from all staff | ☐ | ☐ | ☐ | ☐ | ☐ |
| D8. Have equal influence to the leadership team members | ☐ | ☐ | ☐ | ☐ | ☐ |
| D9. Are able to step into a project leadership position if necessary | ☐ | ☐ | ☐ | ☐ | ☐ |

## Section E: Competencies of your organization

Please provide the following information about your organization by ticking the appropriate response category.

| | Your organization supports… | Totally disagree | Disagree | Neutral | Agree | Totally agree |
|---|---|---|---|---|---|---|
| | | | | | | |
| E1.1 | Leadership | ☐ | ☐ | ☐ | ☐ | ☐ |
| E1.2 | Line Management drive | ☐ | ☐ | ☐ | ☐ | ☐ |
| E1.3 | The deployment facilitator's role | ☐ | ☐ | ☐ | ☐ | ☐ |
| E1.4 | Continuous improvement | ☐ | ☐ | ☐ | ☐ | ☐ |
| E1.5 | A structured approach to Black Belt selection | ☐ | ☐ | ☐ | ☐ | ☐ |
| E2.1 | Employee empowerment | ☐ | ☐ | ☐ | ☐ | ☐ |
| E2.2 | Rewards and recognition | ☐ | ☐ | ☐ | ☐ | ☐ |
| E2.3 | A community spirit of improvement | ☐ | ☐ | ☐ | ☐ | ☐ |
| E2.4 | Sharing of improvement initiatives with all stakeholders | ☐ | ☐ | ☐ | ☐ | ☐ |
| E2.5 | Cross functional collaboration - vertically and horizontally | ☐ | ☐ | ☐ | ☐ | ☐ |
| E3.1 | Building skills across the organization | ☐ | ☐ | ☐ | ☐ | ☐ |
| E3.2 | Consistency of training in DMAIC | ☐ | ☐ | ☐ | ☐ | ☐ |
| E3.3 | Ongoing training without compromise | ☐ | ☐ | ☐ | ☐ | ☐ |
| E3.4 | Quality learning and knowledge gathering | ☐ | ☐ | ☐ | ☐ | ☐ |
| E3.5 | Coaching and mentoring of others | ☐ | ☐ | ☐ | ☐ | ☐ |
| E3.6 | Builds on previous initiatives e.g. Total Quality Management, Business Process Reengineering | ☐ | ☐ | ☐ | ☐ | ☐ |
| E4.1 | Participation in a team environment and an understanding of team dynamics | ☐ | ☐ | ☐ | ☐ | ☐ |
| E4.2 | Rewards for team based improvements | ☐ | ☐ | ☐ | ☐ | ☐ |
| E4.3 | A structured approach to improvement project selection and management | ☐ | ☐ | ☐ | ☐ | ☐ |
| E5.1 | Collecting good data and performance measures | ☐ | ☐ | ☐ | ☐ | ☐ |
| E5.2 | A zero defects mentality | ☐ | ☐ | ☐ | ☐ | ☐ |
| | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| 5.3 | The embedding of the Lean Six Sigma program within the Quality Management system | ☐ | ☐ | ☐ | ☐ | ☐ |
| E5.4 | The focus on improvements of processes | ☐ | ☐ | ☐ | ☐ | ☐ |

Finally, do you have any other comments about the deployment of Lean Six Sigma?

Thank for your contribution:
Roger Hilton
DBA Candidate
Monash University
SCERH Approval 2004/669

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