University of Strathclyde Engineering

Six Sigma Implementation in UK Manufacturing SMEs: An Exploratory Research

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Signed:

Date:

Dedication

To my dear son ‘Ayush’ & my wife ‘Manisha’

You both brought sunshine and happiness to my life

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It would have been impossible to complete this thesis without the help and support of various individuals.

I wish to express my deep appreciation and sincere gratitude to my supervisor Prof. Jiju Antony for all his patience, invaluable guidance, and support throughout my PhD. His encouragement throughout my PhD journey has given me the confidence to develop both my professional knowledge and career. I am indebted to Prof. Umit S. Bititci, whose comments and suggestions have improved the quality of my thesis. I am also thankful to the University of Strathclyde for providing me with the scholarship to pursue my doctoral research and which made this thesis possible.

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Abstract

Though the benefits of Six Sigma were widely reported in many large organizations, research had shown its implementation in the UK small and medium-sized enterprises (SMEs) was still less evident. The aim of this exploratory research was to assess the status of Six Sigma implementation in the UK manufacturing SMEs and thereby develop a customized practical framework to facilitate successful implementation of Six Sigma in SMEs. A mixed method approach of survey and multiple case studies during three phases of research was adopted to achieve the aim of the research by answering the following key research questions (RQs): ***RQ1:*** *What makes SMEs different from large organizations?;* ***RQ2:*** *What are the critical differences in quality management practices of Six Sigma and non-Six Sigma SMEs?;* ***RQ3:*** *What are the critical success factors and barriers to implementation of Six Sigma in SMEs?;* ***RQ4:*** *Does the performance of Six Sigma firms differ from non-Six Sigma firms?;* ***RQ5:*** *How to assess the readiness of a SME to embark on Six Sigma journey?.* The adoption of a mixed method approach not only facilitated in answering the five RQs and but also addressed the quality research criteria of reliability and validity for this research.

This exploratory research had made some significant contributions to the theory and practice of Six Sigma research in SMEs. This is among very few studies in quality management (QM) literature that presents the differences in the characteristics of SMEs and large organizations through the lens of small business growth models. It also identified the similarities in the critical success factors (CSFs) stated for small business growth and for the implementation of continuous improvement (CI) initiatives in SMEs. The research dispels the myth that Six Sigma implementation is limited to large organizations only. The empirical research had indicated successful implementation of Six Sigma in SMEs of sizes ranging from 35 to 240 headcount. A well-designed quality management system (QMS) based on the principles of ISO 9000 could be the foundation to embark on Six Sigma journey. Networking with government bodies or academic institutions and the role of middle managers were identified as two new factors for successful implementation of Six Sigma in SMEs. This was among very few studies that compared and identified significant differences in the performance of Six Sigma SMEs compared to non-Six Sigma SMEs. The Six Sigma firms out-classed non-Six Sigma firms with respect to the nine performance metrics established from the literature.

The two key practical contributions of this doctoral research were the construction of a Six Sigma Readiness Index (SSRI) and a customized Six Sigma framework for SMEs based on the findings from empirical research and literature. The SSRI can assess SME preparedness for Six Sigma implementation. The proposed framework would help SMEs to get started with Six Sigma implementation. The readiness index and framework were tested in three SMEs to assess its robustness and validity. The generalisability of the findings was limited due to the smaller sample size of participating firms from the UK manufacturing sector only. Future research will expand the scope of the study by focusing on global SMEs (manufacturing and services) and conducting exploratory and explanatory research on Six Sigma implementation in SMEs. The author will also test the proposed SSRI and the framework for further refinement and validity.

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Keywords

AHP	Analytical Hierarchy Process
AQA	Australian Quality Award
BB	Black Belts
BEM	Business Excellence Model
BPR	Business process re-engineering
BQF	British Quality Foundation
BRC	British Retail Consortium
BSI	British Standard Institute
CI	Continuous Improvement
CIP	Continuous Improvement Process
COPQ	Cost of Poor Quality
CSFs	Critical Success Factors
CTQ	Critical to Quality Characteristic
D & B	Dun & Bradstreet
DFSS	Design for Six Sigma
DMAIC	Define-Measure-Analyze-Improve-Control
DoE	Design of Experiment
DTI	Department of Trade and Industry
EC	European Commission
EFQM	European Foundation for Quality Management
EMS	Environmental Management System
EQA	European Quality Award
EQMS	Enterprise Quality Management System
ERP	Enterprise Resource Planning
EU	European Union
FD	Finance Director
FMEA	Failure Mode and Effect Analysis
GB	Green Belts
GDP	Gross Domestic Product
IIP	Investors in People
ISO	International Organisation for Standardisation
ISSSP	International Society of Six Sigma Professionals
JIT	Just-in-Time
KI	Key Ingredients
KPIs	Key Performance Indicators
KT	Knowledge Transfer
KTP	Knowledge Transfer Partnership
MAS	Manufacturing Advisory Services
MBNQA	Malcolm Baldrige National Quality Award
MD	Managing Director
MI	Manufacturing Institute
MNC	Multi National Corporation

NEPA	North East Productivity Alliance
NSSS	Non-Six Sigma SMEs
OECD	Organization for Economic Co-operation and Development
OEE	Overall Equipment Effectiveness
OEMs	Original Equipment Manufacturers
OTIF	On Time In Full
OTT	Other Tools and Techniques
PCB	Printed Circuit Board
PMS	Performance Measurement System
QFD	Quality Function Deployment
QI	Quality Initiatives
QP	Quality Program
QM	Quality Management
QMS	Quality Management System
R&D	Research and Development
RQs	Research Questions
SBA	Small Business Administration
SC21	21st Century Supply Chains
SCM	Supply Chain Management
SCORE	The SME Collaborative Research scheme
SEEKIT	Scottish Executive Expertise, Knowledge & Innovation Transfer programme
SMAS	Scottish Manufacturing Advisory Services
SMEs	Small and Medium Sized Enterprises
SPC	Statistical Process Control
SPSS	statistical package for social sciences
SQM	Strategic Quality Management
SSRI	Six Sigma Readiness Index
SSS	Six Sigma SMEs
TOC	Theory of Constraints
TPM	Total Productive Maintenance
TPS	Toyota Production System
TQM	Total Quality Management
VOC	Voice of Customer
VSM	Value Stream Mapping
YB	Yellow belts

Chapter 1

Introduction

1.0. Introduction

This chapter introduces the topic and key research questions to be explored to assess the status of Six Sigma implementation in the UK manufacturing small and medium-sized enterprises (SMEs). The motivation to pursue research in the area of Six Sigma dates back to the author's engineering days when he got an opportunity to be involved in a Six Sigma project at a major automobile manufacturer in India. This project exposed the author to the disciplined methodology of Six Sigma that resolved a chronic problem of the organization and resulted in significant bottom-line savings. To further explore the efficacy of the Six Sigma business improvement initiative, the author decided to pursue higher studies in the UK and fortunately obtained a scholarship to undertake his Masters in Research Program at the Glasgow Caledonian University. It was during his Masters Dissertation that the author was exposed to the emerging area of Six Sigma application in SMEs in the UK. The author was involved in a three months project, as a part of his Masters Dissertation, in a local manufacturing SME to explore the feasibility of Six Sigma application in the SME environment. It was interesting to observe that characteristics of SMEs were different from large organizations and thus any quality improvement frameworks or models required customization for its application in a SME environment. The pilot study motivated the author to pursue doctoral research in this unexplored area and develop a customized framework for Six Sigma implementation in SMEs. The next section explains the background to the study and the rationale for pursuing research on Six Sigma implementation in SMEs.

1.1. Point of Departure

The two decades had witnessed an explosion of research into the role of SMEs within a national and global context, resulting in a considerable body of academic literature and thinking (Lloyd-Reason and Sear, 2007). SMEs constitute the bulk of enterprises in all economies of the world and contribute significantly to the private sector output and employment (Lee, 1998; Antony *et al*., 2008; Kumar, 2007). Though the awareness of the contribution of SMEs is now widespread, their importance is still often underestimated (North *et al*., 1998).

There had been an implicit assumption that organizational theories, models, and conceptual frameworks developed in large organizations were relevant and directly applicable to SMEs (Tonge, 2001). There are indeed significant differences between SMEs and their large counterparts (Penrose, 1959; Storey, 1994; Ghobadian and Gallear, 1996) in the way they run their business and embraces theories and models proposed by academics or practitioners (Kumar *et al.,* 2006). More details on economic contribution of SMEs to the world economy and its differences with large organizations were discussed in Chapter 2.

In recent years, thinking about quality issues has spawned a host of quality management strategies. The changing needs of the stakeholder, economic pressures and developing technology is imposing pressure on organizations worldwide to significantly modify the way they do things, thus driving their businesses towards more rapid change (Oakland and Tanner, 2006). In an attempt to manage change, many large organizations have pursued formalised change programmes or quality initiatives such as Six Sigma, Lean, Total Quality Management (TQM) that had significant impact on the bottom-line and the working culture of organizations. Moving into the 21st century, a new management strategy proposed by Motorola in the mid-1980s called Six Sigma, brought revolution in the industry worldwide and became the long term business strategy to achieve competitive advantage and to excel in operations excellence (Snee and Hoerl, 2003). Six Sigma provided business executives and leaders the strategy, methodology, infrastructure, tools and techniques to change the way businesses were run (Antony *et al*., 2008). As quoted by a leading quality expert: **"***Six Sigma has been very successful-perhaps the most successful business improvement strategy of the last 50 years***"** (Montgomery, 2005).

Six Sigma has evolved significantly and has continued to expand since its inception at Motorola in the mid-1980s to improve the process performance, enhance business profitability and increase customer satisfaction (Antony, 2008a). Six Sigma was considered as one of the most effective improvement initiative in multinational organizations such as GE, Motorola, Honeywell, Bombardier, ABB, Sony, to name a few from the long list, with its adoption showing an upward trend (Snee, 2004; Desai, 2006). The research on the ‘quality’ efforts / initiatives in SMEs compared to large firms is limited (Kuratko *et al*., 2001). The few articles that do appear on SMEs tend to be conceptual with little empirical findings. Continuous improvement (CI) programs like Six Sigma do not appear to be easily understood or interpreted by SMEs, which may be a significant contributor to its low implementation (Antony *et al*., 2005).

The issue of whether quality management programs can be effectively utilised by SMEs remains uncertain (Husband, 1997). Common quality models, such as quality systems and certifications, were adopted by some SMEs, though the rate of implementation was lower than in larger organisations (Brown and Wiele, 1995; Terziovski *et al*., 1997). More holistic quality management initiatives, such as TQM also appears to exhibit low implementation rate (Ghobadian and Gallear, 1996; Wiele and Brown, 1998). It was suspected that the poor adoption of quality management initiatives in SMEs was due to multiple and complex reasons, not just the often-stated impediments of cost, time and relative impacts (Gome, 1996). Chapter 3 included detailed information on the application and impact of CI initiatives in SMEs. In spite of a number of Six Sigma success stories in large organizations, many SMEs are yet to be convinced of benefits from the introduction, development, implementation and deployment of Six Sigma within their business functions (Antony et al., 2005, 2008; Antony, 2008b; Kumar, 2007*).*

The rationale for selecting SMEs as a subject matter of investigation was two-fold. First, SMEs constitute the bulk of enterprise with the major contribution to private sector output and employment in all economies of the world (Lin, 1999; Antony *et al*., 2005, 2008; Kumar, 2007). Secondly, due to growing importance of supply chain issues and pressure from original equipment manufacturers (OEMs) to improve the quality of products or services have forced SMEs to embark on initiatives like Six Sigma (Antony *et al*., 2005, 2008). Large firms were focusing on their core processes/ products that provided competitive advantage and outsourced other processes /products manufacturing to their supply chain partners, i.e. in most cases SMEs. SMEs play a key role in supply chain management (SCM) as they participate in value creation activities: supply raw materials, manufacture products, and distribute finished goods to customers (Hong and Jeong, 2006).

Moreover, other reason to consider the implementation of Six Sigma in SMEs was because SMEs implementing ISO 9000 and TQM faced challenge to improve their performance level (Deas, 2004). SMEs view quality systems such as ISO 9000 as the destination of the achievement of quality. However, this trend is also common in many large organizations as well. In fact, quality improvement is always meant to be a journey rather than mere destination. It is imperative for SMEs to understand the application of process improvement strategies from their larger counterparts and continuously strive for process excellence by implementing initiatives like Lean and Six Sigma. It is in the best interests of all SME stakeholders, whether employees, customers or suppliers, to adopt the best management practice in order to compete in today's global marketplace (Kumar, 2007; Antony, 2008b).

As Six Sigma was more widely recognized as a route to business excellence in many large organizations, they have realized the need for involvement and training of their suppliers (i.e. SMEs) in Six Sigma to have significant financial-benefits for both parties (Antony, 2008b). In order to explore the practicality of Six Sigma implementation within the UK manufacturing SMEs, this research attempts to answer key research questions discussed in the next section.

1.2. Research Aims and Questions

There is paucity of literature on the application of Six Sigma in SMEs. To date, very few seminal works were reported in the literature. SMEs being the backbone of any developed economy need to embrace new business strategies like Six Sigma that may have significant impact on their bottom-line results and bring about cultural transformation within their organisation. *The aim of this research was to assess the status of Six Sigma implementation in UK manufacturing SMEs and thereby develop a customized practical framework to facilitate successful implementation of Six Sigma in SMEs.* This can be realised by first understanding the critical differences between SMEs and large organizations followed by exploratory research on the status of the Six Sigma implementation in SMEs. The aforementioned aim can be achieved by answering the following research questions (RQs).

RQ1: What makes small and medium-sized enterprises different from large organizations?

Comparing the differences between SMEs and large organizations would justify the point that models and frameworks proposed for large organizations is not applicable in a SME context. Addressing this question would set a platform to develop a customized framework for Six Sigma implementation in SMEs, which is the aim of this research.

RQ2: What are the critical differences in the quality management practices of Six Sigma and non-Six Sigma SMEs?

The starting point to identify the differences in Six Sigma and non-Six Sigma SMEs was to compare their quality management (QM) practices and comment on the differences between two clusters, i.e. Six Sigma and non-Six Sigma SMEs. This question would enhance our understanding of QM practices across the two clusters. *The difference between the definition of Six Sigma and non-Six Sigma SMEs was explained in Chapter 6. Here we can assume that Six Sigma and non-Six Sigma firms are adopter and non-adopter of Six Sigma respectively.*

RQ3: What are the critical success factors (CSFs) and barriers to implementation of Six Sigma in SMEs?

Identification of CSFs and impeding factors would facilitate the design of a customized framework for Six Sigma implementation in SMEs.

RQ4: Does the performance of Six Sigma firms differ from non-Six Sigma firms?

A set of metrics would be used to compare the impact on organizational performance after the implementation of different quality improvement initiatives. The results would be used to check the relationship between organizational performance and Six Sigma implementation.

RQ5: How to assess the readiness of a SME to embark on Six Sigma journey?

This question would address the most important part of research- to know whether a SME is ready to embark on the Six Sigma journey or not. The readiness of a SME was assessed across five factors identified from literature and empirical research.

Addressing all five-research questions facilitated in the construction of Six Sigma implementation framework for SMEs.

1.3. Scope of Research

Similar to industrial projects, doctoral research also requires very strong understanding of project management skills to finish the project on time. It is not only important to narrow down the research focus but also to understand the resources at your disposal (time, money, and technical capability) to address the key research questions. The author started with a very ambitious goal, i.e. boiling the ocean project, of including global SMEs in the study and conducts a global survey to understand the status of Six Sigma implementation in SMEs. More understanding of the research methodology and resources available during the period of study facilitated in narrowing down the research focus to European SMEs and further down to UK SMEs, as demonstrated in figure 1.1.

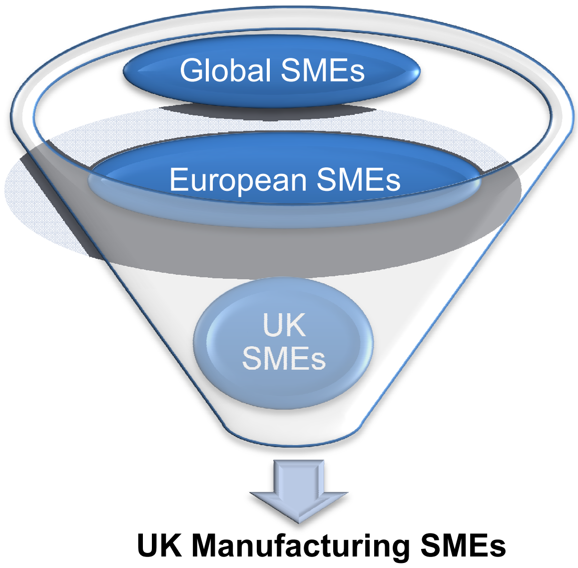

Figure 1.1: Funnel illustrating the scope of doctoral research

Due to critical differences in the characteristics of manufacturing and service sector, the author further narrowed down the focus of study to the UK manufacturing SMEs. CI initiatives like Lean, TQM, and Six Sigma originated in large manufacturing organizations and its application are still less evident in UK service organizations as compared to large manufacturing organizations (Antony, 2004b, 2006; Antony *et al*., 2007). Therefore, the probability of application of the aforementioned initiatives is likely to be found more in manufacturing SMEs as compared to service SMEs. This fact was also confirmed in a pilot study conducted by Antony *et al*., (2005) on Six

Sigma implementation in the UK SMEs. Micro enterprises (headcount less than 10) were also excluded from the study as their characteristics, structure, and operations differ significantly from SMEs. The constraint of time and monetary support was another reason for narrowing down the focus to the UK manufacturing SMEs only.

The purpose of this research was to identify SMEs implementing Six Sigma and perform a comparative analysis with non-Six Sigma firms [includes SMEs implementing TQM, Kaizen, and having certification such as ISO 9000] with respect to the quality management practices existing within SMEs. The study aimed to identify differences in quality management practices and organizational performance, if it exists, between Six Sigma and non-Six Sigma firms. *However, no attempts were made to compare the findings of the research with existing literature on Six Sigma implementation in larger organizations.* The research also attempts to demystify the statement – '*Six Sigma is only for large organizations*'.

1.4. Structure

The structure of the Dissertation is as follows:

Chapter 1 gives an outline of research, motivation to conduct this research, background of the study, establishing research aims and questions, and defining the scope of research.

Chapter 2 includes review of literature on the growth cycle of small firms, and factors critical to the growth of SMEs. This chapter helps in formulation of the first research question (RQ1) and partly attempts to address the question towards the end of the chapter by comparing differences in characteristics of SMEs against large organizations

Chapter 3 starts with an introduction to the CI journey and narrows the focus to discussion on Six Sigma and its applicability in a SME environment. This was followed by extensive review of literature on quality management practices in SMEs; CSFs and barriers to implementation of CI initiatives; impact of CI initiatives on the performance of SMEs; CI maturity models; and CI frameworks for SMEs. This chapter helps in the formulation of RQ2-RQ5.

The purpose of **Chapter 4** and **Chapter 5** was to understand the research philosophy and research strategies appropriate to this research. Rationale for the choice of particular philosophies, approaches, strategies, data collection methods and quality criteria were addressed in the aforementioned chapters. The two chapters also included discussion on design of the survey instrument and case-study questionnaire to address the research questions established in chapter 1.

Chapter 6 presents the analysis of the survey instrument using SPSS 15.0 and Microsoft Excel worksheet. The author focuses more on descriptive statistics to explicate the findings, though inferential statistics were also used occasionally to establish the association or relationship between two variables. This chapter partly addresses questions RQ2-RQ4 and sets the platform to conduct multiple case studies in selected SMEs.

Chapter 7 outlines the findings from the multiple case studies conducted in ten UK manufacturing SMEs, and semi-structured interviews conducted with practitioners of Scottish Manufacturing Advisory Services (SMAS), Manufacturing Advisory Services (MAS) in England, and Manufacturing Institute (MI) in Manchester. The findings highlight the critical differences in quality management practices of Six Sigma firms compared to non-Six Sigma firms. This chapter also addresses questions RQ1-RQ5.

Chapter 8 includes cross-case analysis of ten case study firms. Findings were compared with the first phase of research and with the literature. The discussion of key findings from empirical research compared with the literature facilitated in the development of Six Sigma Readiness Index (SSRI) and customized framework for Six Sigma implementation in SMEs, discussed in chapter 9.

The author proposes a SSRI (RQ5) and a customized framework for Six Sigma implementation in SMEs in **Chapter 9**. The index and framework were designed by comparing the findings from the primary and secondary research.

The thesis concludes in **Chapter 10**, where the key findings from the study were summarized; contribution to theory and practice illustrated; and recommendation made for future research in this area.

1.5. Summary

The chapter starts with the introduction to the author's background and motivation to pursue the research on Six Sigma implementation in SMEs. Reviewing the literature and regular discussion with the author's supervisor facilitated in formulating five research questions to address the research aim established in Section 1.2, i.e. *the aim of this research is to assess the status of Six Sigma implementation in UK manufacturing SMEs and thereby develop a customized practical framework to facilitate successful implementation of Six Sigma in SMEs.* The scope of the research was clearly defined by taking into account the resources and time-frame available to finish the doctoral study. The structure of the dissertation was also illustrated and brief explanations on the contents on ten chapters were provided. The next chapter discusses the growth of small firms and their critical differences with large organizations.

Chapter 2

Introduction to SMEs

2.0. Introduction

The last two decades have witnessed an explosion in researching the role of SMEs in the global economy, which has resulted in a significant body of academic literature and thinking (Lloyd-Reason and Sear, 2007). However, models and theories proposed by academics for SMEs were fragmented and atomised, poorly addressing the solutions to problems that businesses actually encounter (Aldrich and Martinez, 2001). SMEs form the backbone of the European Economy (European Commission, 2003) and represent the fastest growing sector of the economy. Their role is vital to promote entrepreneurial spirit and innovation in the European Union (EU) and thus crucial to ensure EU competitiveness. They support numerous large companies and institutions and therefore have a great bearing on the economy as a whole.

This chapter reviews the definition of SMEs, its economic contribution, understanding the growth of small firms and its comparison with large businesses.

2.1. Definition of SMEs

SMEs are defined as non-subsidiary independent firms, employing less than a given number of employees (OECD, 2000). This number varies across the globe. As defined by the Bolton Committee in its 1971 report on small firms: small firm is an independent business, managed by its owner or part-owner and having a small market share (Lukacs, 2005). The report also recognised that size is relevant to sector and it is appropriate to define size by number of employees in some sectors but more appropriate to use turnover in others. In different sectors, the Bolton committee provided different definitions based on the criteria of head count, sales turnover, physical assets, and ownership (as shown in table 2.1). This definition received several criticisms as it created confusion in understanding the compatibility between the ‘economic’ and ‘statistical’ definition of SMEs. Though the definition states that small business is managed by its owner or part owners, it is strongly argued that a business with 200 employees would not have any formal management structure for decisions making.

Table 2.1: Definition of small firms as per Bolton Committee report

Sector	*Definition*
Manufacturing	< 200 employees
Construction Mining and quarrying	<25 employees
Retailing Miscellaneous Services	Turnover of £50,000 or less
Motor trades	Turnover of £100,000 or less
Wholesale trades	Turnover of £200,000 or less
Road Transport	Five Vehicles or less
Catering	All excluding multiples and brewery-managed houses

Source: Bolton, 1971

Despite governments and many of the multinational organisations targeting this group for special financial business support, there was no single definition for a SME either nationally or internationally. The European Union (EU) definition of SMEs had the upper threshold limit of 250 employees. However some countries set the limit as 200 employees, other countries like US considers SMEs to include fewer than 500 employees.

In the USA, the definition of small business is set by a government department called the Small Business Administration (SBA) Size Standards Office. SBA provides different size standard between different industries, for e.g. in manufacturing and mining industries, SMEs encompasses less than 500 employees, whereas the wholesale trade industries should have less than 100 workers to be classified as SMEs. Canada and Mexico use the same definition for enterprises in the manufacturing sector. In some countries the definition of SMEs varies depending on the industry to which the enterprise belongs, e.g. in Hong Kong, a manufacturing SME has fewer than 100 employees and a non-manufacturing SME has fewer than 50 employees; in Mexico the upper limit is 500 employees for the industrial sector and 100 employees for commercial and service sectors. In Japan, SMEs are defined as follows: enterprises in the mining, manufacturing, transportation and construction industries with less than 300 employees; enterprises in the wholesaling industry with less than 100 employees; enterprises in the retail industry and service industries with less than 50 employees. In countries like Russia, there is no clear definition of SMEs.

The European Commission (EC) adopted a new definition for SMEs on May 8th 2003 due to the result of inflation, productivity increase since 1996, and growing awareness of the many hurdles confronting SMEs (European Commission, 2003). The new definition was implemented from 1st January 2005 and classification based on the definition is provided in table 2.2. The statistical definition of a SME was classified into three defining measurements; number of employees, turnover, or the size of the balance sheet.

Table 2.2: European Commission definition of SMEs

Enterprise category	Headcount	Turnover (Euro)	Balance sheet total (Euro)
Micro	0-9	< 2 million (previously not defined)	< 2 million (previously not defined)
Small	10-49	< 10 million (in 1996: < 7 million)	< 10 million (in 1996: < 5 million)
Medium	50-249	< 50 million (in 1996: < 40 million)	< 43 million (in 1996: < 27 million)

Source: European Commission, 2003

The new definition aims to

- Promote micro enterprises
- Improve access to capital
- Cut administration burdens
- Increase legal certainty
- Promote innovation and growth
- Improve access to research and development

In the UK, sections 382 and 465 of the Companies Act 2006 define SMEs as follows: a small company has a turnover of not more than £5.6 million, a balance sheet total of not more than £2.8 million and employing not more than 50 people; a medium-sized company has a turnover of not more than £22.8 million, a balance sheet total of not more than £11.4 million and not more than 250 employees.

To adhere to one common definition of SME, this research considers an organization to be an SME if it has less than 250 employees as stated by EC (2003) and Department of Trade and Industry (DTI) (2006). However, other constraints of annual turnover or balance sheet are also considered important by the author and were included in the definition, as presented in table 2.2. Since this research is focused on manufacturing SMEs, the quantity seems to fit with EC or DTI definition of SMEs. One of the limitations of varying SMEs definition was performing data analysis if a global survey on different aspects of SMEs was conducted. A company with 499 employees would certainly have different constraints as compared to SME with 49 employees. There would be a difference in organizational infrastructure, decision making, management style, resources available, interaction with customers and suppliers, to name a few, when performing a comparative global study on SMEs.

2.2. SMEs contribution to World Economy

SMEs play a vital role in the economic structure of almost every country. Its contribution to world economy can be gauged from the information provided in table 2.3. In terms of number of enterprises, US has the highest number of SMEs (25.82 million in 2005) followed by Russia (8.73 million in 2003) and Japan (5.64 million in 2004). The percentage contribution in terms of the number of enterprises exceeds more than 90 % in almost every country. In European Union, SMEs are economically important with 98% of an estimated 19.6 million enterprises defined as SMEs. The statistics in table 2.3 clearly indicate the importance of SMEs in the economic growth of any country. According to the recent survey by Small Business Service (SBS), an agency of the Department of Trade and Industry (DTI) in the UK, out of 4.5 million business enterprises, 99.9% were SMEs [99.3% were small (0-49) with only 0.6 % (27,000) of medium sized (50-249)] and 0.1% (6000) were large companies (DTI, 2006).

Table 2.3: Contribution of SMEs to world economy

Item **Country/ Region**	**Industry**	**No. of Employees**	**Non-Agricultural sector of SMEs**		**SMEs Share of Total Sales Turnover**
			% share of all Enterprises	% share of total employment	
UK (2006)	All Sector	250	99.9%	58.9%	51.9%
European Union (2006)	All Sector	250	99.8%	67.1%	52%
USA (2006)	Manufacturing	500	99.9%	50.9%	50.7%
Australia (2004)	Manufacturing	200	95%	47%	-
Canada (2005)	Manufacturing	500	99.7%	64.0%	-
Mexico (2006)	Manufacturing	500	99%	72%	52%
Japan (2004)	Manufacturing	300	98.94%	79.56%	48.20% (2002)
	Wholesale	100			
	Retail & Service	50			
South Korea (2004)	Manufacturing, Mining, Construction and transportation	300	99.8%	86.5%	NA
	Large wholesalers, hotels, information processing companies	300			
	Others	100-200			
Taiwan (2006)	Manufacturing, Mining, Construction and transportation	200	97.77%	76.66%	29.84%
	Other Industries	50			
Malaysia (2006)	Manufacturing	150	99.20%	31.3%, manufacturing	32%
	Services	50			
Thailand (2003)	Manufacturing & Services	200	99.8%	67.6%	47.91 %
	Wholesaling	50			
	Retailing	30			
Singapore (2003)	Manufacturing & Services	200	99.67%	69.10%	75.68%

Sources: UK: Department of Trade and Industry, /www.sbs.gov.uk/
European Union: Eurostat Website: http://ec.europa.eu/eurostat/

USA: Small Business Administration, /www.sba.gov/advo/
Australia: Department of Industry, Tourism and Resources, /www.industry.gov.au/
Canada: Department of Industry, /strategis.ic.gc.ca/
Mexico: SMEs in Mexico, Issues and Policies, OECD 2007
Japan: Statistics Bureau, /www.stat.go.jp/
South Korea: Small and Medium Business Administration, /www.smba.go.kr/
Taiwan: White Paper on Small and Medium Enterprises in Taiwan, consecutive years.
Malaysia: Small and Medium Industries Development Corporation, /www.smidec.gov.my/
Thailand: Office of SMEs Promotion, /cms.sme.go.th/
Singapore: Ministry of Trade and Industry, /www.mti.gov.sg/

In the UK, SMEs economic significance and contribution in generating income and sustaining employment has been widely recognised by the government and policy makers (Jayawarna *et al*., 2003). In terms of employment and annual turnover, SMEs account for 58.9 % and 51.9% respectively and had an estimated combined turnover of £2600 billion (DTI, 2006). At the start of 2005, out of 4.3 million enterprises, the number of SMEs in the manufacturing sector was 332,130 (97.3% were small and 2.2% medium-sized enterprises). In terms of turnover and employment within the manufacturing sector, SMEs contributed to 35.5% of annual turnover and provided employment to 54.2% of population (DTI, 2006).

SMEs in the European Union provided jobs to 67.1% of employees and more than half (52%) of private sector turnover (EUROSTAT, 2003). As presented in table 2.3, the contribution of SMEs in the countries like Japan, South Korea, Taiwan, Malaysia, and Singapore are significant in terms of employment and turnover. In most of these countries, SMEs contribution to employment is more than 60% (higher than the western part of the world). However, the turnover varies from as low as 29.84% (Taiwan) to as high as 75.68% (Singapore). In the Organization for Economic Co-operation and Development (OECD) Countries, SMEs represent over 95% of enterprises in each of the 30 member countries and generate over half of private sector turnover (OECD, 2003). 99% of all enterprises in China are SMEs, providing employment to 75% of total workforce (China's Services SMEs, 2002).

In can be concluded from the above discussion that the success of SMEs will have everlasting impact on the competitiveness of the knowledge-based economy in the world, ensuring sustainable economic growth, creating more and better jobs, and developing greater social cohesion.

2.3. Understanding the growth of small firms

SMEs are the backbone of the modern economy, contributing significantly to gross domestic product (GDP) and job creation of any developed or developing countries. Yet, it is startling that theoretical and empirical understanding of the characteristics and growth pattern of these firms remains somewhat fuzzy (Phelps *et al*., 2007; Dobbs and Hamilton, 2007; Levie and Hay, 1998; Storey, 1994). *The purpose of reviewing the growth models for small businesses was to identify the key characteristics of the firm as it metamorphoses into a large organization.* The identification of key attributes would facilitate in commenting on what makes small firms different from their larger counterparts. The review would also identify the critical success factors (CSFs) driving the growth of small firms and their transition into large organizations. The CSFs of small business growth would be compared with the CSFs of CI initiatives in SMEs to identify the similarities or differences in the listed factors. *If a small business is growing and exhibiting the CSFs of growth, it may be the indication that they are also ready for embarking on CI journey, provided the CSFs of CI matches with the CSFs of small business growth.*

The first attempt towards the development of general theory of the growth of firms was addressed by the economist Edith Penrose in 1959. Penrose (1959) clearly defined what we mean by ‘firm’ and provided a detailed treatment of the various aspects of the growth process in the firm, drawing out the theoretical implications for economists of a more realistic view of the business world. The researcher clearly distinguished between the characteristics of small firms and large firms and points out - “*the differences in the administrative structure of the very small and the very large firms are so great that in many ways it is hard to see that the two species are of the same genus……we cannot define a caterpillar and then use the same definition for a butterfly*”. This led to the emergence of the first research question that seeks to understand the critical differences in the characteristics of SMEs compared to large organizations.

RQ1: *What makes SMEs different from large organizations?*

The exposition of Penrose encouraged researchers to investigate the stages of metamorphosis associated with the firm’s growth. The term ‘growth’ is defined by researchers using measures such as sales (Barringer *et al*., 2005; Delmar *et al*., 2003;

North and Smallbone, 2000; Smallbone *et al*., 1995), headcount or employment (Delmar *et al*., 2003; Davidsson and Delmar, 1997; Freel and Robson, 2004; North and Smallbone, 2000), financial growth (Becchetti and Trovato, 2002; Pena, 2002; Orser *et al*., 2000), and total assets (Carpenter and Peterson, 2002). Empirical research in the past has tried to explain the phenomenon of small business growth. Summaries of important reviews of the literature on life cycle or growth of small firms can be found in Dobbs and Hamilton (2007), Phelps *et al* (2007), Levie and Hay (1998), Hanks *et al* (1993), and Gibb and Davies (1990). It was also identified from literature that not all small firms want to grow as the owner of small firms prefers status–quo and control over entire organization.

Dobbs and Hamilton (2007) classified the approaches to study the life cycle of small business into six broad categories: stochastic; descriptive; evolutionary; resource-based; learning; and deterministic. For the purpose of this research, the review is limited to only three approaches, i.e. *descriptive, deterministic and learning approaches,* to identify and understand the critical factors affecting the transition of small firms into large organizations, rather than understanding 'how' the transition occurs in all the categories discussed by Dobbs and Hamilton (2007). The details of the descriptive and deterministic approaches were provided in Appendix I. The author has included discussion on one of the approaches proposed by Dobbs and Hamilton (2007), i.e. learning approach, to study the life cycle of small business. The learning approach takes into account the role of operational improvement in the growth of small business, which was previously not included in any of the growth models study (Phelps *et al*., 2007).

The factors identified as critical to the growth of small firms from descriptive and deterministic approaches are listed in table 2.4 and table 2.5. Concluding from the review of *descriptive stage models*, determinants of small business growth, as listed in table 2.4 are: strong leadership; management commitment; strategic planning; formal organizational structure; focus on human resources; information planning and control mechanism; and flexibility. Several factors critical to the growth of firms from the *deterministic approach* were identified and listed in table 2.5. *Organizational structure, planning, communication, strategy, top-management decision making, management style, resources, rewards, organizational size and age* were the common factors emerging from the review process.

Table 2.4: Determinants of small business growth from descriptive approach

	Lippitt and Schmidt (1967)	Steinmetz (1969)	Greiner (1972,1998)	Churchill and Lewis (1983)	Quinn and Cameron (1983)	Scott and Bruce (1987)
Factors considered imperative during the growth process	Leadership Goal Setting Communication of goals and objectives Planning Systematic control Flexibility Team decision-making	Management Style Return on Investment Size of firm Assets Owner Status Leadership style	Management Focus Organizational Structure Leadership Style Control System Management Reward Emphasis	Owner's strategic, managerial and operational abilities Extent of formal systems Information, Planning and Control mechanism Strategic planning Owner's involvement in the business. Matching of business and personal goals People	Planning and goal Setting Marshalling resources Communication & Information management Elaboration of structure Formalization of rules Flexibility People	Role of top management Management style Organization structure Product and market research Systems and controls Major sources of finance Cash generation Major Investment Product-market issues

Table 2.5: Determinants of small business growth from deterministic approach

	Smith *et al* (1985)	**Kazanjian (1988)**	**Gupta and Chin (1993)**	**Hanks *et al* (1993)**	**Mitra and Pingali (1999)**	**Shim *et al* (2000)**	**Barringer *et al* (2005)**
Factors considered imperative during the growth process	Organizational Structure Communication process Planning Top-level decision making Organizational age and size Organizational growth rate Reward system	Resource Technology Formal structure Process and planning	Leadership from CEO Strategy making Environment focus Structure Communication Process and Planning Top-level decision making Organizational age and size Innovation	Formal policies and procedures Communication Organizational structure Rewards and incentive Planning. Top-level decision making	Customer focus Customer base *(number of customers)* Management Style Managerial capability Managerial orientation *(long-term vs. short term)* Managerial goals *(immediate vs. long-term)* Business Strategy *(low-risk vs. high risk)* Human resource policy	Resource Management Human resource focus Management style Top-management decision making Formal operational business system Entrepreneurial talent	Customer Knowledge Tertiary education Mission statement Commitment to growth Inter-organizational relationship Industry experience of founder Financial incentives

The *learning approach* takes into consideration the capability of an organization to absorb and use new knowledge (i.e. absorptive capacity) in resolving the challenges or barriers faced during the transition, termed as crisis point / revolution/ tipping point (Cohen and Levinthal, 1990; Zahra and George, 2003; Bessant *et al*., 2005; Macpherson, 2005; Phelps *et al*., 2007). Phelps *et al* (2007) criticized the stage models discussed in descriptive approaches (Appendix I) and proposed a 'state' framework for the growth of firms, as shown in figure 2.1 below.

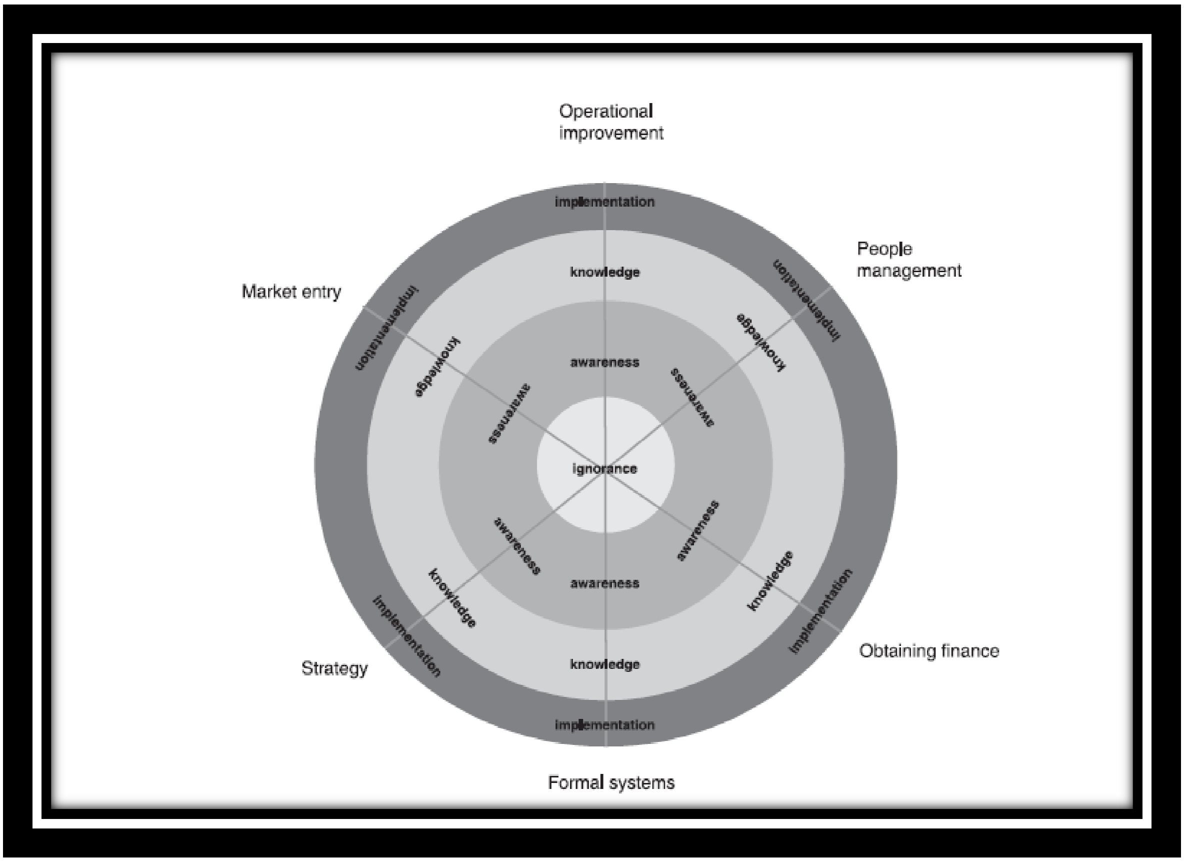

Figure 2.1: The tipping point in a state framework for growth of firms

(Source: Phelps et al., 2007)

Unlike stage framework, state framework does not predict sequence of stages characterized by increasing size and age, as observed in the stage models. The state framework consists of two elements: tipping point- describes the problems faced by firms; absorptive capacity- describes the firm's ability to absorb and use new knowledge in resolving the challenges presented by tipping points (Phelps *et al*., 2007). From the work of Phelps *et al* (2007), the six critical factors responsible for the growth of firms were- Strategy; Formal system; People management; Obtaining finance; Operational improvement; and Market entry. Operational improvement was a new factor that emerged from this study and was not discussed previously in the stage models (can be observed from table 2.4 and table 2.5). *There exists a research gap concerning the lack of understanding and knowledge on the types of operational improvements that are of specific value for growing SMEs.* The a*uthor doctoral research on feasibility study of CI initiatives in SMEs attempts to bridge the existing gap by addressing the different alternatives available for SMEs to improve their operational performance.*

Phelps *et al* (2007) states that there is no standard sequence of stages or problems and the growing firms will encounter a basic set of key issues, i.e. tipping point, at some point in the life cycle. Similar to the CI maturity model that describes a organization moving from no formal CI structure to full CI [learning organization] (Bessant and Caffyn, 1997), Phelps *et al* (2007) proposed a series of possible learning states that the growing firm may occupy, i.e. ignorance, awareness, knowledge, and implementation, as shown in figure 2.1. Interventions are required at each state, internally or externally, for firms to raise their absorptive capacity and ascend from the state of ignorance to state of implementation with respect to each tipping point. For more information on the framework, please refer to Phelps *et al* (2007). *The strength of this model over the stage model was that it does not predict the point/time when the organization would experience a crisis. The model rather states that the tipping point would be experienced during the growth period (any point of time as the firm grows into a large organization) of small firms and interventions were required to overcome the crisis.*

The key to growth within the learning perspective was the acquisition of external knowledge (Cohen and Levinthal, 1990; Zahra and George, 2003) to become aware of key issues a firm faces and provide solutions to successfully traverse through the crises and challenges generated at the tipping point (Bessant *et al*., 2005; Phelps *et al*., 2007). The emphasis here is on entrepreneurs or firms' acquisition of external knowledge, their ability to recognize the value of new information, assimilating it, and applying it to commercial ends to allow their business to grow. One of the limitations of the model was testing its robustness with large number of SMEs and to further develop the understanding of firm's absorptive capacity, tipping points and interventions required to get growing firms successfully through the tipping points.

Factors identified as critical in explaining the growth of firms were also reported by Dobbs and Hamilton (2007) and Storey (1994), after a thorough review of literature. Critical factors that have a positive impact on the growth of firms as identified in the study were: commitment and motivation of the owner(s); availability of financial resources; employee skill level; collaboration and networking; experience and education of the entrepreneur; management recruitment; management experience; planning; market adjustment; new product introduction; and technological sophistication. A firm's age and size had a negative impact on a firm's growth, i.e. young or small firm grow faster than mature or large firms. Factors such as workforce training and the size of the founding team had a mixed effect on a firm's growth. For more information please refer to Dobbs and Hamilton (2007) and Storey (1994).

Taking cue from the key findings of the aforementioned three approaches, characteristics of SMEs were explained in reference to the identified critical factors from the literature. Factors critical to the growth of small firms were depicted in the cause and effect diagram in figure 2.2. In the figure 2.2, the effect is '*the growth of small firms*' and the causes of growth are '*the critical factors'* governing the growth as identified from the literature.

The common critical factors identified from the literature on small business growth are: *leadership, management style, strategic planning, organizational structure, systems and procedures, human resources, market & customer focus and operational improvement*. Surprisingly, the last two factors were not commonly cited in the literature, which plays a vital role in the growth of firms (Mitra and Pingali, 1999; Shim *et al*., 2000; Barringer *et al*., 2005; Phelps *et al*., 2007). Any CI initiative like Lean or Six Sigma begins and ends with the customer and emphasises on improving the organizational performance (Antony and Banuelas, 2002).

The three approaches to small business growth failed to take into account other factors such as *innovation* (Rothwell, 1989; Nooteboom, 1994; Birchall *et al*., 1996; Vossen, 1998; Karlsson and Olsson, 1998; McAdam and Armstrong, 2001; Humphreys *et al*., 2005; Laforet and Tann, 2006) and *networking* (Ostgaard and Birley, 1994; Barbosa and Fuller, 2007; Mazzarol, 2007; Chen and Huang, 2004), which play an important role in small business growth in the era of globalization. As customer's demand changes quickly, firms need to be flexible and innovative in manufacturing customized products or delivering customized services to their customers. Networking is equally critical for small firms to mitigate the effect of limited resources in the growth of firm. *As the author's research is focused on implementation of Six Sigma in SMEs, it is imperative to identify the critical factors that ensure the successful implementation of Six Sigma. The identification of critical factors of small business growth was used to compare with findings from the empirical research in Chapter 8.*

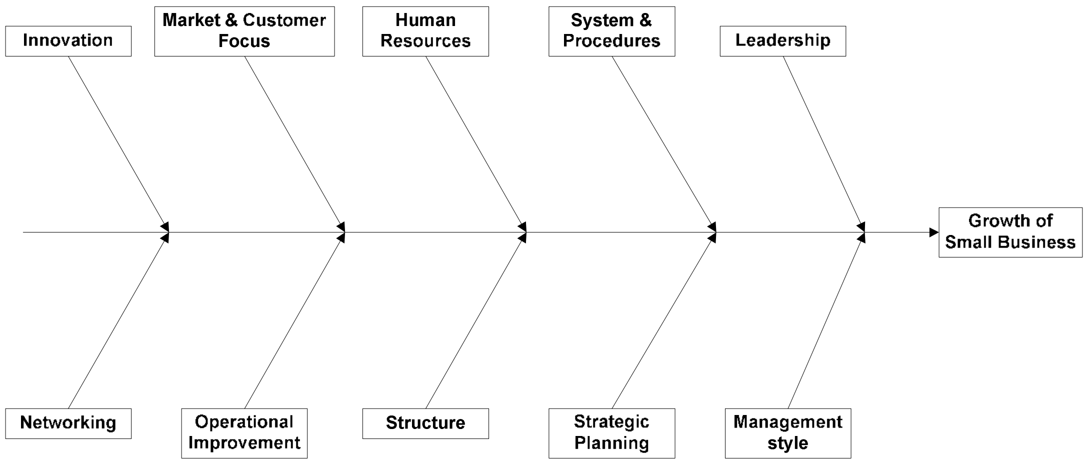

Figure 2.2: Critical success factors for the growth of small businesses

Based on the aforementioned CSFs, the next section will discuss the key characteristics of SMEs with respect to each factor and its comparison with large organizations. The review in the next section also includes literature on CI initiatives implementation in SMEs along with the growth cycle of small firms. Quality management literature was introduced in discussion where the CSFs of small business growth matched with those proposed for quality management implementation in SMEs. Commonality in the CSFs of small business growth and implementation of CI initiatives in SMEs can be drawn from the literature review in chapter 3.

2.4. SMEs characteristics and comparison with large organizations

The characteristics of SMEs were discussed in relation to the identified CSFs from the literature, as presented in the table 2.6. Table 2.6 also focus on the changes observed in these factors as the small firm matures into a large organization. Each dimension of business growth i.e. CSFs, varies in its characteristics as the firm grows from small to large business. The characteristics of SMEs and their differences with large organizations in relation to each critical factor were briefly discussed in this section.

2.4.1. Leadership

The factor identified to be of most importance to the survival and growth of small firms in the UK was the capabilities and skills of the owner / entrepreneur (Carter *et al*., 2000: 7). Before discussing the importance of leadership qualities of entrepreneurs in small firms, an introduction to the characteristics of entrepreneurs was briefly discussed. It was stated that entrepreneurs were the energizers of small businesses, possessing typical characteristics such as total commitment to the business and strong belief (Dewhurst and Burns, 1993); opportunity-driven (Penrose, 1959); innovators (Dewhurst and Burns, 1993; Soderquist *et* al., 1997; McAdam and Armstrong, 2001; Laforet and Tann, 2006); versatile with a natural need for achievement (Dewhurst and Burns, 1993); and risk takers (Soderquist *et* al., 1997; McAdam and Armstrong, 2001). In the research undertaken by Storey (1994) to understand the growth of small firms, entrepreneurial factors identified as having a positive impact on the growth of firms were motivation, education, management experience (before starting the business), number of founders, and functional skills. Some of the aforementioned traits of entrepreneurs were also required to demonstrate strong leadership.

A SME success often hinge on its owner’s leadership skills characterised by unity of ownership, management, liability and risk. However, the majority of owners of small firms lack the necessary administrative skills and therefore managerial culture was almost absent (Greiner, 1972; Churchill and Lewis, 1983; Scott and Bruce, 1987; Wessel and Burcher, 2004; Garengo *et al*., 2005a). The general finding in SMEs was lack of time available for the leader to undertake anything other than operational activities (Garengo *et al.,* 2005a). Due to flat organizational structure and limited resources, the ownership and management of day-to-day operational activities rest with the owner / leader in SMEs compared to larger organisations where leadership is shared to a greater extent, dispersed and institutionalised. The ability of the leader to free him/her from mundane operational concerns and to focus on the longer-term strategic future of the organisation was seen as a key challenge in SMEs (Ghobadian and Gallear, 1996; Garengo *et al.,* 2005a).

2.4.2. Management Style

The management in small businesses were mostly through direct supervision or supervised supervision by owner(s)/manager(s) as compared to delegation or decentralization of responsibilities to employees as witnessed in large firms (Greiner, 1972, 1998; Churchill and Lewis, 1983; Scott and Bruce, 1987). Control by the owner/ manager of everything may stifle the growth process in small firms. Understanding management of small firms was an essential component in perceiving the relationship between ownership and decision making, managerial styles, organizational structure and culture, and pattern of business development (Beaver and Prince, 2004).

Due to the flat structure of SMEs, the owner/ manager have a good understanding of operational issues, processes, customer needs, and are more likely to be involved with the customers (Ghobadian and Gallear, 1996; Cagliano *et al*., 2001; Youssef *et* al., 2002; Deros *et al*., 2006). Top management in the large organization was far removed from the point of delivery due to division of function, labour, and creation of multiple level of authority (Ghobadian and Gallear, 1997; Beaver and Prince, 2004). The ownership of large firms was usually distanced from its management and control, which was not evident in the majority of SMEs. Large organizations were usually bureaucratic, relying on formalization of behaviour and delegation of responsibilities at the department/functional level to achieve co-ordination.

2.4.3. Strategic Planning

A critical appraisal of strategic planning literature on SMEs (Shrader *et* al., 1989; Baker *et al*., 1993; Berry, 1998; Barnes, 2002; Sum *et al*., 2004; Beaver and Prince, 2004) suggests that strategic activities were informal, intuitive, invisible, and often owe more to a speedy response than an in-depth analysis (as demonstrated in large firms). Management decision in SMEs is often based on imprecise information and subject to fluctuation. This may be attributed to the volatile and short-term nature of contemporary markets encompassing the SME. SMEs exist in uncertain and dynamic environment, where innovation, flexibility, and responsiveness may be vital for survival. Strategic planning is often viewed as inappropriate. In such firms, the strategic process was emergent and instinctive rather than fixed and regulated as in many large firms. This approach was more appropriate and efficient for SMEs to deploy when integrating their business activities with the competitive environment (Beaver and Prince, 2004). Owners-managers in SMEs were driven more by survival and independence than by growth and business development (Storey, 1994; Burns and Dewhurst, 1996). In such cases, focus on niche strategies was considered to be more realistic for small firms, owning to their inherent resource disadvantages (Curran and Blackburn, 1994; Tolentino, 2000). The strategic planning employed by a firm was contingent upon its stage of development and this activity may evolve and become more formal and sophisticated over the life-cycle of the business (Greiner, 1972; Scott and Bruce, 1987; Storey, 1994; Berry, 1998; Phelps *et al*., 2007).

2.4.4. Structure

SMEs have flat organizational structure, i.e. fewer levels of management, and fewer departmental interfaces promoting a flexible work environment (Shea and Gobeli, 1995; Ghobadian and Gallear, 1996, 1997). Faster communication, quick decision making process, faster implementation, and less resistance to change were some advantages of the flat structure for SMEs compared to their larger counterparts. Large organizations have higher degree of formalization, standardization, and specialization compared to the organic nature of small firms, i.e. absence of standardization and the prevalence of loose and informal working relationships (Yusof and Aspinwall, 2000 a, b; Youssef *et al*., 2002; Garengo *et al*., 2005a; Deros *et al*., 2006). Tidd *et al*. (2001) strongly argued that flat organizational structure and streamlined business processes were good in short-term to have an efficient and productive business, though in the long-term this would not promote the development of innovative products or services, and thereby was sidelined to respond to ever changing market and technology.

2.4.5. System and Procedures

The extent of formal systems in small firms ranges from minimal/non-existent to basic level compared to large firms, where they have mature and formally established systems and procedures in place (Churchill and Lewis, 1983; Scott and Bruce, 1987; Ghobadian and Gallear, 1996; Yusof and Aspinwall, 2000a, b; Deros *et al*., 2006). Simple bookkeeping or eyeball/ personal control were characteristics of the small firm, which transforms to a formal control system and management by objectives as the firm grows larger. The simple processes in SMEs allowed flexibility, encouraged innovation, and speedy response to customer needs/ demands (Deros *et al*., 2006). Though the SME have the advantage of flexible and adaptable processes, they still use the informal evaluation, control and reporting procedures; thus promoting decisions based on gut-feeling.

2.4.6. Human Resources

It is easier in the SME environment to educate and train employees due to the smaller workforce compared to their larger counterparts. The time required to cascade training to shop-floor employees was very much shorter. However, due to scarcity of resources (intellectual capital, human resources, and financial capability) or facilities to deliver effective programs (Yusof and Aspinwal, 2000 a; Thomas and Webb, 2003; Wessel and Burcher, 2004), SMEs struggled to allocate sufficient funds for training despite training needs of employees being identified (Lee and Oakes, 1995; Ghobadian and Gallear, 1996; McAdam, 2000). Because of the limited resources, there may be a problem to find out the time for training as every employee has a key role (often many) (Moreno-Luzon, 1993). Training and staff development in SMEs was more likely to be adhoc and small scale compared to the planned and large scale training in larger firms. High personal authority, commitment and responsibility of the owners in SMEs may create cohesions and enhance a common purpose among the workforce to ensure the job gets done (Yusof and Aspinwall, 2000 a, b; Youssef *et al*., 2002; Deros *et al*., 2006). The evaluation, reward and reporting system was simpler in SMEs and the individual normally can see the results of their endeavours.

2.4.7. Market and Customer Focus

Research in the USA and Europe (Ghobadian and Gallear, 1996, 1997; Haksever, 1996; Yusof and Aspinwall, 2000 a, b; Youssef *et al*., 2002; Garengo *et al*., 2005a, b; Deros *et al*., 2006) have clearly shown that SMEs are more responsive to market needs, more adaptable to change, and more innovative in their ability to meet customer needs (Haksever, 1996; Moreno-Luzon, 1993; McAdam and Armstrong, 2001). SMEs are very close to their products and customers that allow faster information flow between customers and the company, creating an increased sense of responsibility. Many successful SMEs deliberately choose to exploit a particular market segment where they can either specialize in quality improvements not offered by large firms or attain a cost advantage by offering a particular expertise or specialized knowledge (Beaver and Prince, 2004). SMEs are normally dependent on a small customer base (in a local or regional market) with limited external contacts. On the contrary, larger firms have a wide span of activities dispersed externally with greater scope for a large customer base.

2.4.8. Operational Improvement

As defined by Phelps *et* al. (2007), operational improvement signifies "*a move from 'if it ain't broke don't fix it' towards an awareness and understanding of process capabilities and the implementation of best practices oriented towards efficiency gains and avoidance of error*". Implementation of best-in-class management practices such as TQM, Lean, Six Sigma, and Kaizen, to name a few, in large organizations is well documented and cited in literature (Banuelas and Antony, 2002; Antony *et al*., 2005). However, existing evidence suggests that SMEs were slower to adopt such formalized management practices due to lack of understanding of system, lack of resources and knowledge, and short-term strategic planning (Garengo *et al*., 2005b; Kumar, 2007; Phelps *et al*.,2007; Antony *et al*., 2008). The understanding of operational improvement activities and its measurement will force small firms to do strategic planning, implement solutions, and identify gaps between the company's current performance and its objectives.

Fact-based management using the concept of performance measurement system (PMS) is particularly imperative for supporting managerial development required in SMEs to manage increasing complexity (Garengo *et al*., 2005b). Implementation of PMS (very rarely observed practice within small firms, where the majority of decisions were based on gut-feeling rather than data collection and analysis) could support decision-making processes in SMEs and facilitate them to improve their management processes, strategic control, and support the culture of continuous improvement (Barnes *et al*., 1998; Neely, 2000; Garengo *et al*., 2005b; Phelps *et al*., 2007).

2.4.9. Innovation

Innovation is a key source of competitive advantage for organizations, as cited in several research studies. There are different schools of thought that have debated the relative merits of small and large firms with respect to innovation (Rothwell, 1989; Nooteboom, 1994; Vossen, 1998; Hallberg, 2003; Tidd *et al*, 2001) and have reached diametrically opposite conclusions. Hallberg (2003) study clearly stated that SMEs have an edge over large organizations with respect to innovation, while Tidd *et al* (2001) argues that SMEs were not always more innovative.

The relative advantage of large firms lies mostly in making use of their resources/economies of scale and good external networking, while SMEs are relatively strong in innovation where effects of scale are not important as compared to their behavioural attributes including entrepreneurial dynamism, efficient network co-operation, flexibility, proximity to market demands, and motivation (Rothwell, 1989; Nooteboom, 1994; Birchall *et al*., 1996; Vossen, 1998; Karlsson and Olsson, 1998). Some of the other reasons cited in the literature that promotes innovation in small firms were increasing global competition, demand from customer for cost reduction, input from their own research & development (R&D) department (Soderquist *et al*., 1997; Birchall *et al*., 1996) and firms having a history of successful CI initiatives, which build a successful innovative culture (McAdam *et al*., 1998; McAdam and Armstrong, 2001). Research had demonstrated that SMEs conducted R&D more efficiently compared to their larger counterparts, who may be more R&D intensive but less efficient (Vossen, 1998; Acs and Audretsch, 1990; Nooteboom, 1994; Soderquist *et al*, 1997).

Summarising the findings from the past research, factors identified as critical to SMEs innovative performance were entrepreneurial dynamism, commitment of CEOs/ owners (Rothwell, 1983, 1989; Nooteboom, 1994; Birchall *et al*., 1996;Vossen, 1998; McAdam *et al*., 2000; Humphreys *et al*., 2005); corporate culture (Oakey and Cooper, 1991; Dogson and Rothwell, 1991; Laforet and Tann, 2006); innovation linked to strategic business plan (Soderquist *et* al., 1997; Laforet and Tann, 2006); efficient network co-operation (Oakey and Cooper, 1991; Mitra, 2000, North et *al*., 2001; Terziovski, 2003); organizational structure, flexibility, short communication, proximity to market demands, and motivation (Rothwell, 1983, 1989; Pavitt, 1991; Nooteboom, 1994; Birchall *et al*.,1996; Soderquist *et* al., 1997; Vossen, 1998; Karlsson and Olsson, 1998; Chandler *et al*., 2000; McAdam *et al*., 2000; Humphreys *et al*., 2005; Laforet and Tann, 2006); CI of work processes and procedures (McAdam *et al*., 1998; McAdam and Armstrong, 2001; Humphreys *et al*., 2005). Though, it was also emphasized that effective innovation must involve all areas of a SME, to affect every discipline and processes (Humphreys *et al*., 2005). Impeding factors to innovation, as identified from literature, were customer dependency, skill and knowledge acquisition through training, resources and networking (McAdam *et al*., 2000; Humphreys *et al*., 2005; Laforet and Tann, 2006).

2.4.10. Networking

Networking and alliances play an important role in the development of skills of entrepreneurs in small firms and provide them with an opportunity to build strategic market positions that offer enhanced competitive advantage. It further helps in creating new market value, widening range of customers or the reach of products, increase in sales channels, better understanding of emerging technologies, and sharing of best-in-class practices (Ostgaard and Birley, 1994; Barbosa and Fuller, 2007; Mazzarol, 2007; Chen and Huang, 2004).

Research had shown that SMEs were better able to innovate when they were part of clusters (Mitra, 2000, North et *al*., 2001). Creation of Science Parks promotes clustering of firms, where networks of small firms may interact with each other to mitigate the effect of lack of resources. Local Universities also play a key role in disseminating latest technical knowledge to small firms through collaborative programs such as Knowledge Transfer Partnership (KTP), Scottish Executive Expertise, Knowledge and Innovation Transfer programme (SEEKIT) , and the SME Collaborative Research scheme (SCORE) to name a few. However, very few SMEs were aware of the existence of such support available from Government Bodies or Universities (North et *al*., 2001; Thomas, 2007). Thus, to strengthen the innovative capability of the SMEs, a more strategic and co-ordinated approach to providing innovation support was needed.

Summarising the findings from the literature review, the key distinction between SMEs and large organizations with respect to critical factors of business growth was presented in the table 2.6. Table 2.6 was constructed by reviewing existing literature on the life-cycle of SMEs and Quality Management practices such as TQM and Six Sigma (Greiner, 1972, 1998; Churchill and Lewis, 1983; Smith *et* al., 1985; Scott and Bruce, 1987; Kazanjian, 1988; Hanks *et al*., 1993; Ghobadian and Gallear, 1996, 1997; Mitra and Pingali, 1999; Noci and Toletti, 1998; Yusof and Aspinwall, 2000 a, b; McAdam, 2000; Levy and Powell 2000; Cagliano *et* al., 2001; Castellanos, 2001; Youssef *et* al., 2002; Garengo *et* al., 2005a,b; Barringer *et* al.,2005; Deros *et* al., 2006; Phelps *et al*., 2007; Dobbs and Hamilton, 2007; Kumar, 2007; Antony *et* al., 2008).

Table 2.6: Critical differences between SMEs and large organizations

Factors critical to growth of firm	SMEs	Large organizations	References
Leadership	- Entrepreneurial, individualistic - Leader more involved in operational activities	- Professional, administrative - Leaders more involved in strategic planning	Ghobadian and Gallear, 1996; Garengo *et al.,* 2005a; Carter *et al*., 2000; Churchill and Lewis, 1983; Wessel and Burcher, 2004
Management style	- Direct supervision or supervised supervision - Top management close to the point of delivery - Owners have better understanding of processes, operational issues, and customer needs - Mostly organic - Corporate mindset	- Participative; decentralization of authority - Top management a long distance away from the point of delivery - Formalization of behaviour and delegation of responsibilities to achieve co-ordination - Mostly Bureaucratic - Strong departmental / functional mindset	Ghobadian and Gallear, 1996; Cagliano *et al*., 2001; Youssef *et* al., 2002; Deros *et al*., 2006; Beaver and Prince, 2004; Greiner, 1972, 1998; Churchill and Lewis, 1983; Scott and Bruce, 1987
Strategic planning	- Short-term planning with focus on niche strategies	- Both short and long-term planning	Shrader *et* al., 1989; Baker *et al*., 1993; Berry, 1998; Barnes, 2002; Sum

	- Strategic activities are informal, intuitive, invisible - Strategic process is emergent and instinctive - Decision based on imprecise information and subject to fluctuation	- Planning based on in-depth analysis - Strategic process is fixed and regulated	*et al*., 2004; Beaver and Prince, 2004; Greiner, 1972; Scott and Bruce, 1987; Storey, 1994; Berry, 1998; Phelps *et al*., 2007
Structure	- Flat with few layers of management - Low degree of specialization - Flexible structure and information flow - Top management highly visible - Single-sited - Very few interest groups - Unified culture	- Hierarchical with several layers of management - High degree of specialization - Rigid structure and information flow - Top management's visibility limited - Multi-sited or multi-national - Many interest groups - Cultural diversity	Shea and Gobeli, 1995; Ghobadian and Gallear, 1996, 1997; Yusof and Aspinwall, 2000 a, b; Youssef *et al*., 2002; Garengo *et al*., 2005a; Deros *et al*., 2006; Tidd *et al*.,2001
System & Procedures	- simple bookkeeping, eyeball/personal control - Low degree of standardization and formalization - People dominated - Flexible and adaptable processes - Decision based on gut feeling more prevalent - Few decision makers	- Formal control systems, management by objectives - High degree of standardization and formalization - System dominated - Rigid and inadaptable processes - Decisions based on fact more prevalent - Fragmented decision makers	Churchill and Lewis, 1983; Scott and Bruce, 1987; Ghobadian and Gallear, 1996; Yusof and Aspinwall, 2000 a,b; Deros *et al*., 2006
Human Resources	- Dominated by pioneers and entrepreneurs - Personal authority mainly high - Individual creativity encouraged - Limited human capital, financial resources and know-how - Training and staff development is more likely to be adhoc and	- Dominated by professionals and technocrats - Personal authority mainly low - Individual creativity stifled - Ample human capital, financial resources and know-how - Training and staff development is more	Yusof and Aspinwall, 2000 a,b; Thomas and Webb, 2003; Wessel and Burcher, 2004; Lee and Oakes, 1995; Ghobadian and Gallear, 1996; McAdam, 2000; Youssef *et al*., 2002; Deros *et al*., 2006

	small scale - Low incidence of unionization - Negligible resistance to change - More generalists, some staff may cover more than one department - Very few internal change catalysts	likely to be planned and large scale - High incidence of unionization - High degree of resistance to change - More specialist staff - Potentially many internal change catalysts	
Market & Customer focus	- Span of activities narrow - Limited external contacts - Limited customer base	- Wide span of activities - Extensive external contacts - Larger customer base	Ghobadian and Gallear, 1996, 1997; Haksever, 1996; Yusof and Aspinwall, 2000 a,b; Youssef *et al*., 2002; Garengo *et al*., 2005a,b; Deros *et al*., 2006; Haksever, 1996; Moreno-Luzon, 1993; McAdam and Armstrong, 2001; Beaver and Prince, 2004
Operational improvement	- Limited knowledge or understanding of operational improvement activities - Slower to adopt such formalized management practices - Poor understanding of performance measurement system - Poor project-management understanding - Process improvement based on gut feeling	- Vast knowledge or understanding of operational improvement activities - High incidence of implementation of CI initiatives - Better understanding of performance measurement system - Better understanding and experience of managing complex projects - Process improvement projects initiated based on facts and data	Garengo *et al*., 2005b; Kumar, 2007; Phelps *et al*.,2007; Antony *et al*., 2008; Banuelas and Antony, 2002; Antony *et al*., 2005; Barnes *et al*., 1998; Neely, 2000
Innovation	- High incidence of innovation - Innovation can represent a disproportionately large financial risk - Inability to spread risk over a portfolio of projects - In some area scale economies form substantial entry barrier	- Low incidence of innovation - Ability to spread risk over portfolio of projects - Ability to gain scale economies in R&D, production and marketing - Research & Development (R&D) activities more	Rothwell, 1989; Nooteboom, 1994; Vossen, 1998; Hallberg, 2003; Tidd *et al*, 2001; Birchall *et al*.,1996; Karlsson and Olsson, 1998; Soderquist *et al*., 1997; McAdam *et al*., 1998; McAdam and Armstrong, 2001; Acs and Audretsch, 1990; McAdam *et al*., 2000; Humphreys *et al*., 2005;

	- Increasing global competition and demand from customers to reduce cost promotes innovation - Research & Development (R&D) activities more efficient - Product innovation stimulated by technology-push	intensive - Product innovation stimulated by both technology-push and demand-pull	Oakey and Cooper, 1991; Mitra, 2000, North et *al*., 2001; Terziovski, 2003; Laforet and Tann, 2006
Networking	- Limited external networking - Limited knowledge of funding and support available from local government bodies or academic institution - Better able to innovate when they were part of clusters	- Extensive external networking - Better understanding of support available from local government bodies or academic institution - In-house capability to perform R & D activities	Ostgaard and Birley, 1994; Barbosa and Fuller, 2007; Mazzarol, 2007; Chen and Huang, 2004; Mitra, 2000, North et *al*., 2001; Thomas, 2007

2.5. Summary

The last several decades have witnessed the majority of organisational research being undertaken in large organisations. In the 1980s, with the globalisation of world market, a continuous trend towards downsizing of large firms and outsourcing of their business to smaller firms was a common trend in the market. With the beginning of the new millennium, SMEs were well recognised and acknowledged worldwide, both nationally and internationally, as vital and significant contributors to economic development, job creation, and the general health and welfare of economies. They form the foundation upon which the UK economy is based. SMEs act as suppliers to large organisations and therefore the ‘footprint’ of SMEs was much larger than may be seen at a first glance.

Though the awareness of the contribution of small enterprises is now widespread, their importance is still often underestimated. There had been an implicit assumption that organisational theories, models, and conceptual frameworks developed in large organisations were relevant and directly applicable to SMEs. This chapter addresses the critical differences between small and large organizations (i.e. **RQ1**) based on the literature review on growth of small firms and implementation of initiatives like TQM and Six Sigma in SMEs. Very few researchers in quality management literature have explained the characteristics of small firms and their differences with large organizations based on literature of small business growth. Understanding of the phenomenon of small business growth and critical factors involved in the transition phase may aid in the successful implementation of any change management programs within the SME environment. There were significant differences between SMEs and their large counterparts in the way they run the businesses and embrace theories and models proposed by academics or practitioners.

The distinction between large and small firms was explained based on the ten CSFs identified from the literature. This chapter led to the emergence of first research question, i.e. RQ1, and also partly answers this question by reviewing the extant literature on small business growth and key articles on CI initiatives in SMEs. The similarity in the CSFs of small business growth and CI initiatives in SMEs indicates that if a small business is growing and exhibiting the CSFs of growth, it may be the indication that they are also ready for embarking on CI journey.

Chapter 3
Quality initiatives in SMEs- A review of literature

3.0. Introduction

The chapter starts with a general literature review on evolution of quality from inspection and testing to implementation of continuous improvement initiatives like TQM, Lean, and Six Sigma in large organizations. Chapter 2 addressed the research question 1 (RQ1) on what makes small and medium-sized enterprises different from large organizations by critically analyzing the literature on the life/growth-cycle of small firms into a large business. The differences between SMEs and its larger counterpart raised question on the applicability of frameworks/models proposed for large organizations in a SME environment. Due to differences in the characteristic of SMEs compared to large organizations, the working principles of framework/models should be tailored to the needs of SMEs by taking into account constraints they experience in running their business. The review of literature on quality management practices and application in SME environment leads to emergence of key research questions for this study. The next section discusses the scope of literature review.

3.1. Scope of review

The focus on quality management research in the last three decades had been on large organizations with minimal interest in researching SMEs. This chapter accentuates on understanding the quality management practices in SMEs by reviewing the extant literature on the implementation of different quality initiatives (QI) or certification system in SMEs. The discussion on application of QI in large organizations was kept to minimum in the first part of the literature review. The review of QI literature in SMEs lead to the identification of the research gap and generation of another four research questions to understand the feasibility of Six Sigma application in SME, an area least researched and reported (Antony *et al*., 2005, 2008; Kumar, 2007). Due to limited literature on Six Sigma application in SMEs, literature review focused more on the application and impact of other CI initiatives such as TQM and Lean in SMEs to generate a picture of quality management practices in SMEs. Initially, ISO application in SMEs was omitted from the literature review as the focus of the study was more on CI initiatives rather than certification systems. However, due to interesting result indicating ISO being foundation to embark on Six Sigma from the first phase of the study, the author decided to include a section on measuring the impact on organizational performance (1) with and without ISO certification (2) TQM (Lean) + ISO certification and only TQM initiative. *To develop a Six Sigma implementation framework for SMEs*, it was imperative to review the efficacy of any existing CI frameworks/ models proposed for SMEs

As the aim of the research and key research questions established in Chapter 1 focused on frameworks, CSFs and barriers, quality management practices, impact of QI on performance of SMEs, the aforementioned keywords were used for searching literature from secondary sources such as journals, conference proceedings, books, professional magazines, and some reliable on-line sources. The databases used to search articles on CI initiatives or certification systems in SMEs with aforementioned keywords were Emerald, ProQuest, Ingenta, and Science Direct that have access to thousands of journals and magazines.

3.2. Evolution of Six Sigma

Before the concepts of TQM and Six Sigma were formalised, much work had taken place over the centuries to reach this stage. The father of scientific management, F.W. Taylor, introduced simple inspection of finished good in late nineteenth century that was followed by several successive phases, with the change in concept of *quality* during last half-century, from compliance with specifications of a product to the entire cycle including product design, production, sales, distribution, use, and disposal (Crosby, 1979; Deming, 1982; Ishikawa, 1985; Feigenbaum, 1991; Payne *et al*., 1996).

In the 1920's statistical theory began to be applied effectively to quality control, and in 1924 Dr. Walter Shewhart made the first sketch of a modern control chart, and currently it is one of the most widely discussed statistical techniques (Deming, 1986). In the early 1950's, quality management practices developed rapidly in Japanese plants with the help of some notable quality gurus – Juran, Deming and Feigenbaum.

A lasting and continuous improvement in quality can only be achieved by directing organizational efforts towards planning and preventing problems occurring at source (Dale and Shaw, 1999). This concept leads to the next phase of quality management development, which was *quality assurance*. Quality Assurance was a prevention-based system, which improved product and service quality and increased productivity by placing the emphasis on product, service and process design (Dale and Shaw, 1999). The features acquired when progressing from quality control to quality assurance were, for example, comprehensive quality assurance procedures to increase uniformity and conformity, use of seven quality control tools, and gathering and use of quality costs (Dale and Shaw, 1999).

On the contrary, the quality revolution in the West was slow to follow, and did not begin until the early 1980's, when companies introduced their own quality programmes and initiatives to counter the Japanese success. A modified form of total quality control was exported to the USA from Japan in the 1970s and later it took the name of TQM (Feigenbaum, 1991, Ahmed and Hassan, 2003).

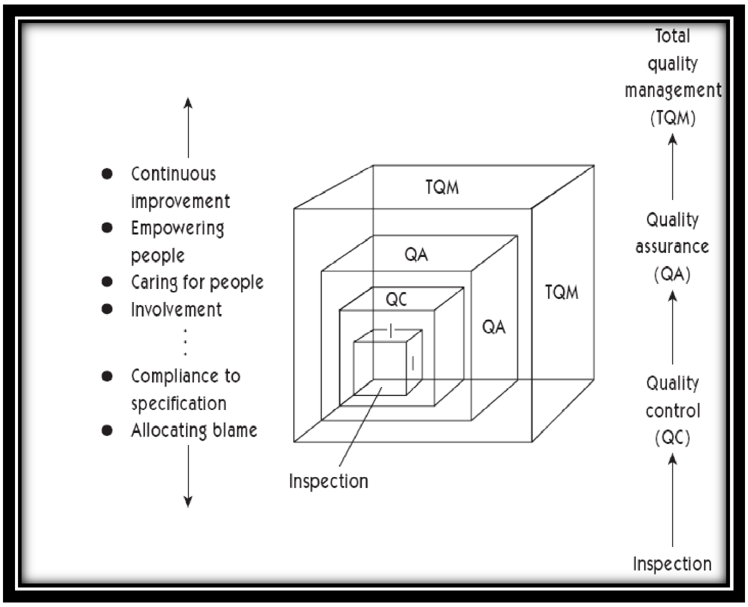

Figure 3.1: Four key stages in the evolution of quality management

(Source: Dale, 2003 pp. 21)

The International Organisation for Standardisation (ISO) followed in 1987 with the ISO 9000 series, which became the internationally recognised standard for quality management systems (Dale and Shaw, 1999). In early 90's in Europe, a widely adopted framework called "Business Excellence" or "Excellence" Model, promoted by the European Foundation for Quality Management (EFQM), and in the UK by the

British Quality Foundation (BQF). Whilst Quality Awards were focus for some users, the true measure of the EFQM Excellence Model's effectiveness was its use as a management system and the associated growth in the key management discipline of organisational self-assessment (Wilkes and Dale, 1998).

Moving into the 21st century, a new management strategy invented by Motorola in mid 1980s called Six Sigma, brought revolution in the industries worldwide and has become the long term business strategy to achieve competitive advantage and to excel in operations excellence (Snee and Hoerl, 2003; Hoerl, 2004). Six Sigma is widely recognized as a methodology that employs statistical and non-statistical tools and techniques to maximize an organization’s Return on Investment (ROI) through the elimination of defects in processes.

Six Sigma has evolved significantly since its inception at Motorola, where the focus was more on defect reduction (termed as Generation I by Harry and Crawford (2005)). The Generation II Six Sigma, lasted from about 1994 to 2000, focused on cost reduction and Generation III (which is currently practiced) focuses on value creation for the enterprises (Harry and Crawford, 2005; Montgomery, 2005). The perception of Six Sigma has changed drastically from being a statistical tool to being a company-wide strategy for business process improvement (Antony and Banuelas, 2002; Kuei and Madu, 2003; Goh, 2002; Zairi, 2002; McAdam *et al.*, 2005; Montgomery, 2005; Kumar *et al*., 2008). Organizations have included Six Sigma as a part of their business strategy and in the strategic review process to become globally competitive, increase market share, and enhance customer satisfaction (Antony and Banuelas, 2002; Kuei and Madu, 2003; Goh, 2002; Zairi, 2002; McAdam *et al.*, 2005).

The Six Sigma approach starts with a business strategy and ends with top-down implementation, having significant impact on profit if successfully deployed (Keller, 2001; Adams *et al*., 2003). It also emphasizes on customer- centric approach to problem solving and establishing good bottom-up /top-down communication system. It takes us away from “*intuition based decisions-what we think is wrong, to fact based decision-what we know is wrong*” (Antony and Banuelas, 2002). A number of papers and books have been published showing the fundamentals of Six Sigma, such as, what is Six Sigma (Ellis, 2001; Park, 2003); why do we need Six Sigma (Magnusson *et al*., 2003; Haikonen *et al*., 2004); what makes Six Sigma different from other quality initiatives (Snee and Hoerl, 2003; Snee, 2004; Kumar *et al*, 2008; Antony, 2009); Six

Sigma deployment (Mitra, 2004; Antony, 2004b); critical success factors of Six Sigma implementation (Antony and Banuelas, 2002; Antony *et al*., 2005, 2007, 2008; Antony, 2004b, 2006; Kumar, 2007; Henderson and Evans, 2000; Mahanti and Antony, 2009); Six Sigma project selection (Harry, 1998; Snee, 2000; Snee and Rodebaugh, 2002; Kumar *et al*., 2009); organizational infrastructure required for implementing Six Sigma (Hoerl, 1998; Antony, 2004b); the role of academia and university in promoting the best-in-class practice of Six Sigma (Harry, 1998; Mitra, 2004; Kumar *et* al., 2008; Antony, 2008a).

3.2.1.Definition of Six Sigma

Linderman *et al* (2003) defined Six Sigma in the following way: *"Six Sigma is an organized and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific method to make dramatic reduction in customer defined defect rate"*. The definition accentuates on the customer's definition of defect and its importance while making a process improvement or when manufacturing a product. . According to Breyfogle *et al.* (2001), "*Six Sigma is a team-based approach to problem solving and process improvement*". Six Sigma's success has been attributed to embracing it as an improvement strategy (Antony and Banuelas, 2001; Snee, 2000), philosophy (Slack *et al*., 2007) and a way of doing business (Pande and Holpp, 2002; Watson, 2001). General Electric (GE) CEO Jack Welch described Six Sigma as *"the most challenging and potentially rewarding initiative we have ever undertaken at General Electric"* (Breyfogle, 1999).

The aim of Six Sigma is to keep the distance between the process average and the nearest tolerance limit to at least six standard deviations and thus reduce variability in products and processes in order to prevent defects (Wiklund and Wiklund, 2002). Six Sigma aims at achieving 3.4 defects per million opportunities (DPMO) with an assumption that the process mean shift by as much as 1.5 standard deviation off the target (Snee and Hoerl, 2003; Linderman *et al*., 2003). A defect opportunity is a process failure that is critical to the customer (Breyfogle, 1999; Linderman *et al*., 2003). The Six Sigma measure of process capability assumes that the process mean may shift over the long-term by as much as 1.5σ, despite our best efforts to control it.

The process capability indices C_p and C_{pk} are used as the vehicles to characterize the produced process quality. Six Sigma is achieved when the product specifications are at $\pm$ 6 σ (where σ is the standard deviation of the process) and when the process width is half the specification band. The process potential (C_p) for a Six Sigma process would be 2 (when the process is centered) and actual process performance (C_{pk}) would be 1.5 (when there is 1.5σ shift in the process mean). Considerable research has been reported about understanding and properly interpreting the process capability indices for stable and unknown trend pattern process (Deleryd, 1998; Palmer and Tsui, 1999; Bothe, 1997; Gunter, 1991; Caryle *et al*., 2000).

Six Sigma is not just about statistics. The Six Sigma drive for defect reduction, process improvement and customer satisfaction are based on the "statistical thinking" paradigm, a philosophy of action and learning based on process, variation and data. Statistical thinking provides practitioners with the means to view processes holistically. There is a logical thought progression from process-variation-data to Define-Measure-Analyse-Improve-Control (DMAIC) (Hare, 2005). This is contrasted with statistical methods and theories which are primarily about variation and data and the aggregate of statistical methods themselves (Snee, 2004; Hare, 2005).

3.2.2. Characteristics of Six Sigma

The attributes of Six Sigma that makes the quality proponents ponder its efficacy over other quality improvement initiatives or programs, were listed below (Antony and Banuelas, 2002; Goh,2002; Kwak and Anbari, 2004; Lee-Mortimer, 2006; Kumar *et al*., 2008; Naslund, 2008):

- **Framework:** Existence of a framework (DMAIC) where techniques like Quality Function Deployment (QFD), Failure Mode and Effect Analysis (FMEA), Design of Experiment (DoE), and Statistical Process Control (SPC) are integrated into a logical flow.
- **Approach:** Top-down approach starting from CEO and involving cross-functional team from quality, sales, marketing, production, and human resource department.

- **Application:** While the original goal of Six Sigma was to focus on manufacturing operations, today marketing, purchasing, billing, invoicing, banking and healthcare functions have also embarked on Six Sigma with the aim of continuously reducing defects or errors and work towards perfection and thereby achieving business excellence.
- **Focus:** Six Sigma applications are customer-centric, listening to the voice of customers (VOC) and measuring it in terms of critical to quality characteristics (CTQs) i.e. mapping the VOC into product/ service characteristics.
- **Organization:** In organizational terms- Six Sigma accentuates on project-by-project feature of its implementation. Six Sigma focuses on project management skills, project selection criteria, and project review involving the cross-functional team.
- **Result:** The outcomes of Six Sigma projects are measured in financial terms that is tangible measure of achievement which most people in the organization understand- not just project members.
- **Personnel:** Six Sigma emphasizes on training, education, and certification processes that result in Black Belts, Green Belts, and Yellow belts before embarking on any project. Belt system (Black, Green, and Yellow) is a unique feature of Six Sigma, creating an infrastructure to assure that performance improvement activities have the necessary resources. They are the change agents that act as a catalyst in institutionalizing cultural change in organization(Pande *et al*., 2000; Antony *et al*., 2007; Kumar *et al*., 2008)

3.2.3. Six Sigma Problem Solving Methodology

A healthy portion of Six Sigma training involves learning the principles behind the methodology that takes the form of projects conducted in phases generally recognized as Define–Measure–Analyze–Improve–Control (DMAIC). The DMAIC methodology is applied for improving the existing processes (Snee, 2004). It is not just the DMAIC methodology which makes the application of Six Sigma successful in organizations; rather it is the collection of tools and techniques which are integrated into DMAIC in a sequential and rigorous manner makes the Six Sigma application successful.

Moreover, DMAIC creates a sense of urgency by emphasizing rapid project completion in 3 to 6 months. The five step Six Sigma methodology (DMAIC) was depicted in figure 3.2.

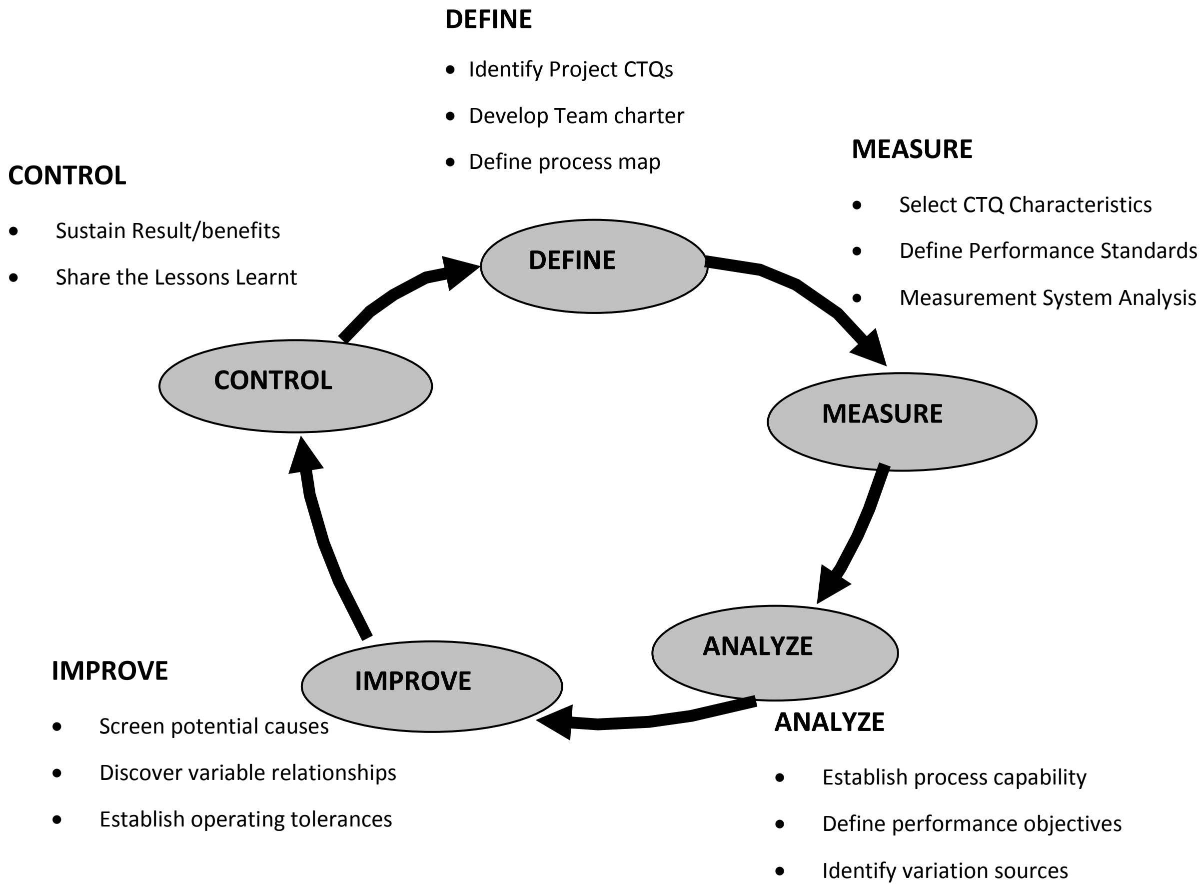

Figure 3.2: The five step methodology of Six Sigma *(Source: Kumar, 2005)*

- **Define Phase:** involves identifying a project's CTQs characteristic driven by the VOC followed by developing team charter and finally defining a high level process map connecting the customer to the process and identifying the key inputs and requirements.
- **Measure Phase:** The goal of this phase is to gather information about the current situation, to obtain baseline data on current process performance, and to identify problem areas.
- **Analyze Phase:** mainly consists of three steps: establishing process capability with the help of capability indices, defining performance objectives by the team benchmarking and identifying the sources of variation by performing analysis of

variance and hypothesis testing. Based on the above information, root causes of defects and their impact on the business/ process can be identified.

- **Improve:** The goal of the Improve phase is to implement solutions that address the problems (root causes) identified during the previous (*Analyze*) phase.
- **Control:** The goal of the Control phase is to put in place ongoing measures to monitor both the process output and the factors that influence output variation, thus ensuring that results achieved in the previous phase is sustained.

3.2.4. Six Sigma versus TQM

It is often said by engineers and managers in small and big companies that there is nothing really new in Six Sigma compared to other quality initiatives witnessed in the past (Antony, 2004a). Companies that have embraced Six Sigma within their working culture previously made improvements through the use of TQM or Crosby’s Zero Defects or Quality Circles (Walters, 2005). However, these programs obviously did not address all of their needs. Otherwise these same organisations would not be spending additional time and money to implement Six Sigma. The CEO of 3M, Chris Galvin, believed that Six Sigma had changed their way of doing business: “*Six Sigma is not a program or an initiative. It is our game plan. It will challenge all of us, as a company and in collaboration with our customers, to be the very best. Motorola was open to sharing the risk, which allowed us to develop an outstanding partnership*” (McShea *et al*., 2004).

In the last few decades, there existed many programs that have purported to be the answer to industry’s process management problems. These include zero defects, management by objectives, quality circles, TQM and Business Process Reengineering (BPR) (Marsh, 2000). While these initiatives enjoyed some success, in the long run most of them were considered as a passing fad by the management and staff of different corporations. Despite the remarkable growth of attention in quality management system during the last two decades, the literature revealed that total quality remains an ambiguous concept, the most important and yet least understood subject for managers (Seddon, 1998; Hansen and Bash, 1999).

Deming, one of the quality Gurus of the 20th century, argued that TQM is terminologically vague, stating *"the trouble with total quality management, the failure of TQM, you can call it, is that there is no such thing. It is a buzzword. I have never used the term, as it carries no meaning"* (Deming, 1994). There is still very little documented evidence of successful deployment of TQM in large and small businesses. It was asserted that TQM was also less visible in many businesses now than it was in the early -1990s (Pande *et al.*, 2000; Naslund, 2008). Figure 3.3 clearly shows the drop in publication of TQM literature in the last decade (indicating it is waning and becoming less-visible) and growing publication of Six Sigma literature. A large number of studies (Anjard 1998; Hansson and Klefsjo 2003; Pande *et al.* 2000; Moser and Bailey 1997; Hellsten and Klefsjo 2000) have shown that 60% to 80% of TQM initiatives fail, or fail to show significant impact on business performance.

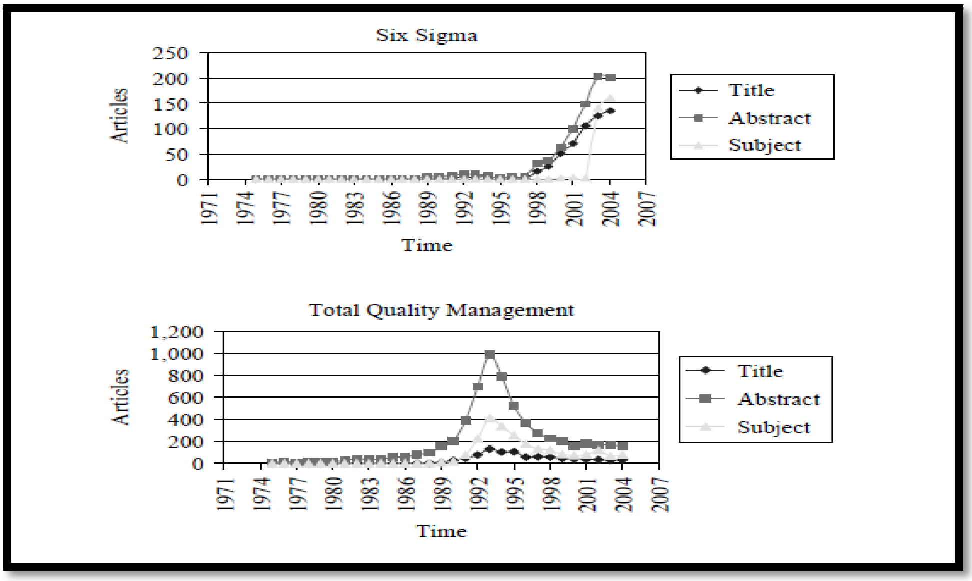

Figure 3.3: Comparison of popularity of Six Sigma and TQM

(Source: Naslund, 2008)

There are three aspects of the Six Sigma strategy that are not emphasised in TQM (Snee, 2004; Kumar *et al.*, 2008). First of all, Six Sigma is result-oriented and therefore places a clear focus on bottom-line business impact in hard dollar savings. No Six Sigma project will be approved unless the team determines the savings generated from it. Secondly, Six Sigma DMAIC methodology links the problem solving tools and techniques in a disciplined and sequential manner (Antony, 2008a). Finally, Six Sigma creates a powerful infrastructure for training of Champions, Master Black Belts, Black Belts, Green Belts and Yellow Belts (Snee 2004; Antony *et al.*, 2005;

Pande *et al*., 2000; Harry and Schroeder, 1999; Adams *et al*., 2003; Schroeder *et al*., 2008). The belt system helps organizations not only to control process improvement activities, but also at the same time creates a context that enables problem exploration between disparate organizational members (Schroeder *et al*., 2008). As compared to other quality initiatives, the cultural change in Six Sigma organisation is facilitated by key players known as Champions and Black Belts, who act as agents to facilitate the change. These change agents harness the power of knowledge to achieve enhanced performance, customer satisfaction and profitability, which is what Six Sigma is all about (Pyzdek, 2003; Brue, 2002). Companies that have deployed Six Sigma have achieved outstanding financial results and developed disciplined, pragmatic plan and approach for improved financial performance and growth.

3.2.5. Six Sigma versus Lean Manufacturing

Lean Manufacturing was another quality initiative proposed by Americans in response to compete with Japanese manufacturers and its superior manufacturing techniques (following the concept of Toyota Production System (TPS) to resolve quality problems in their organization) as their import became serious concern to western producers (Womack and Jones, 1994; Hines *et* al., 2004; Holweg, 2007). Similar to the concept of TPS, which focuses on waste reduction through quality control, quality assurance and respect for people (Ohno, 1988; Monden, 1983), the basic principle of Lean Manufacturing was to reduce cost and enhance the speed of organization by minimizing seven types of waste (overproduction, motion, transportation, inventory, extra processing, waiting, and defect) through everyone involvement and continuous improvement by employing practices such as Just-in-Time (JIT), cellular manufacturing, Total Productive Maintenance (TPM), Kanban, Mistake Proofing, to name a few (Womack *et al*., 1990; Bicheno, 2000; Hines *et al*., 2004; Kumar *et al*., 2006; Shah, 2003,2007; Holweg, 2007; Slack *et* al., 2007).

Lean is considered to be one of the most influential initiative in manufacturing (Womack and Jones, 1996; Fullerton *et al*., 2003; Shah and Ward, 2003) and its application is expanding to service industry, particularly healthcare (Vanden Heuvel *et al*., 2006; Kolberg *et al*., 2007), and public sector (Furterer and Elshennawy, 2005; Sua´rez-Barraza and Ramis-Pujol ,2009). The application of Lean principles have resulted in reduction of wastes, that drove practices such as inventory reduction, process simplification, and identification of non-value added activities and thereby cost reductions and customer satisfaction in many organizations (Hines *et* al., 2004; Shah and Ward, 2003; Holweg and Pil, 2004; Hopp and Spearman, 2004; Browning and Heath, 2009). As stated by Browning and Heath (2009) - "*the implementation of lean principles and practices will reduce waste ..... add to production costs, implementing lean will therefore reduce production costs".*

Six Sigma and Lean Manufacturing are the two most popular and successful programs espoused by the industries over the last few decades. Many companies such as Toyota, Danaher Corporation, General Electric, Motorola and many others have achieved impressive results by implementing either a Lean or Six Sigma methodologies in their organisation (Antony *et* al., 2003; Kumar *et al*., 2006; Arnheiter and Maleyeff, 2005; Bendell, 2006). Proper implementation of the two methodologies had proven to achieve dramatic results in terms of cost, quality, and delivery by focussing on process performance. The effective implementation of each methodology involves top management commitment, cultural change in organisations, good communication down the hierarchy, new approaches to production and to servicing customers and a higher degree of training and education of employees.

However, there are some fundamental differences between the two methods that were presented in table 3.1. It may be inferred from table 3.1 that there are some limitations in both the approaches. Whereas, Six Sigma is closely associated with defects and quality, Lean is linked to speed, efficiency, and waste. Lean provides tools to reduce lead –time of any process and eliminate non-value added cost (Liker, 1998, Askin and Goldberg 2001, Bicheno 2000). Six Sigma does not contain any tools to control lead time (e.g. Pull System) or tools specific to the reduction of lead time (e.g. set up reduction).

Table 3.1: Differences between Six Sigma and Lean manufacturing

Issues/ Problems/ Objectives	Six Sigma	Lean Mfg.
Focus on customer value stream	No	Yes
Focus on creating a visual workshop	No	Yes
Creates Standard work sheets	No	Yes

Attacks work-in-process inventory	No	Yes
Focuses on good house keeping	No	Yes
Process control planning and monitoring	Yes	No
Focuses on reducing variation and achieve uniform process outputs	Yes	No
Focuses heavily on the application of statistical tools and techniques	Yes	No
Employs a structured, rigorous and well planned problem solving methodology	Yes	No
Attacks waste due to waiting, over processing, motion, over production, etc.	No	Yes

(Adapted from Antony et al, 2003)

3.2.6. Common myths of Six Sigma

With more than two decades of successful implementation of Six Sigma methodologies at major corporations, the success and benefits possible with Six Sigma are well documented. Although Six Sigma initiatives have grown in popularity due to its highly publicized reports of success, the strategy is not the panacea that some insist, i.e. Six Sigma still has its limitations. News keeps cropping up about the efficacy of the Six Sigma business strategy from its critics, as a management fad- *a fashion that sweeps the world with great excitement for a brief period of time, usually less than a year, and then disappears* (Swinney, 2005).

There is a pervasive perplexity and misinterpretation of what “Six Sigma” is about. Is “Six Sigma initiative” just an old wine in a new bottle, or has it one or more important learning points, which should be remembered and practiced (Dahlgaard and Dahlgaard, 2006). Is Six Sigma dead, or at least waning in popularity? Is it just a ‘fad’, which can be ignored like most other fads or should companies begin to understand the common realities of Six Sigma? When Six Sigma was introduced to many organisations, the initial reactions varied from a lot of enthusiasm to an absolute scepticism, with the latter mood reflected in comments such as (Kumar *et al*, 2008):

1. Six Sigma is the flavour of the month

2. Six Sigma is all about Statistics
3. Six Sigma is only for manufacturing companies
4. Six Sigma works only in large organisations
5. Six Sigma is same as Total Quality Management (TQM)
6. Six Sigma requires strong infrastructure and massive training
7. Six Sigma is not cost-effective

For detailed information on the demystification of seven myths of Six Sigma, please refer to author's published work on 'Common Myths of Six Sigma Demystified' in International Journal of Quality and Reliability Management (Kumar *et al*., 2008). The article also includes discussion on sustainability issues of Six Sigma and agenda for future research in this area. It is not possible to include the entire findings from the study in the thesis due to word-limit constraint and moreover the focus of this research is more on Six Sigma implementation in SMEs. The author in this research addresses myth 4 by conducting exploratory research in the UK manufacturing SMEs.

3.2.7. Benefits from Six Sigma

The reason of Six Sigma's popularity in the business world is because many corporations have seen how Six Sigma generated substantial return on investment in its implementation (Szeto and Tsang, 2005). Six Sigma has been on an incredible run for nearly two decades, producing significant savings to the bottom-line of many large organizations such as GE, Motorola, Honeywell, Bombardier, Boeing, Caterpillar, Kodak, Lockheed Martin ,Sony, Texas Instrument to name a few from the long list and resulted in millions of dollars of bottom-line savings (Henderson and Evans, 2000; Antony, 2006; Antony *et al*., 2005, 2007; Kumar *et al*., 2006, 2008; Gutierrez *et al*., 2009; Antony and Desai, 2009). It was reported that the savings achieved by Motorola reached $1 billion in 1998 and $16 billion in 2005 (Ingle and Roe, 2002; Brett and Queen, 2005). Dow Chemicals, which implemented Six Sigma on a corporate-wide basis in 2000, achieved its target of $1.5 billion in cumulative EBIT (earnings before interest and taxes) gains by the end of 2002 (Motwani *et al*., 2004). Volvo Cars in Sweden have generated over 55 million euro to the bottom line from Six Sigma programme (Magnusson *et al*., 2003).

Six Sigma application in service industry had grown significantly in last 6-7 years with companies started realising benefits from its implementation in banking and financial services, healthcare, accounting, customer services, public utilities, and even government and non-profit organizations (Bisgaard *et al*., 2002; Antony, 2004b, 2006, Antony *et al*, 2007; Chakrabarty and Tan, 2007; Kumar *et al*., 2008; Chakrabarty and Chuan, 2009). GE Capital, the financial division of GE, was one of the first financial institutions applying this methodology in order to increase their profitability and customer satisfaction (Antony, 2006). After this, various financial institutions and banks have followed such as Bank of America, Citicorp, American Express, UBS, Lloyds TSB, HSBC, Zurich Financial, and Bank One (George, 2003). The first health-care organization to implement Six Sigma fully into its culture was Commonwealth Health Corp. (CHC) in partnership with General Electric (Thomerson, 2001). CHC has realized improvements in excess of $1.2 million, improved radiology throughput by 33 per cent and decreased cost per radiology procedure by 21.5 per cent (Thomerson, 2001). Following CHC, many health-care organizations embraced the Six Sigma challenge within their processes, examples include Mount Carmel Medical Centre (Columbus Ohio), Charleston Area Medical Centre (WV), Palomar Pomerado Health (San Diego, California), the University of Michigan Medical Center, and Wellmark Blue Cross Blue Shield (CA), to name a few (Sehwail, 2003). Six Sigma continues as the best known approach to process improvement (Snee and Hoerl 2003). It is worth noting that Six-Sigma has a lot of air left in its sails and continues to build momentum with no signs of letting up in the near future (Hoerl, 2004; Snee, 2004).

3.2.8. Critique of Six Sigma and Agenda for Future Research

Six Sigma, a systematic framework for quality improvement and business excellence, has been widely publicized in recent years as the most effective means to combat quality problems and win customer satisfaction (Goh, 2002). However, some researchers have argued that the focus of Six Sigma has been too narrow, the research not being well developed, and too much research has been focused on descriptions of practice rather than on theory development that is of use to managers and scholars (Linderman *et al*., 2003; Schroeder *et al*., 2008).

Though Six Sigma had been applied successfully in the service and voluntary sector, still there is dearth of knowledge on the application of tools and techniques packaged within DMAIC methodology tailored to the needs of those sectors. The linkage between Six Sigma and organizational learning is very incoherent and requires more justification. The type of leadership required for successful implementation of Six Sigma is among the least explored topic in Six Sigma research that requires considerable attention for the long-term sustainability of initiative.

The 1.5σ shift assumption was based on findings from the manufacturing industry, in particular from Motorola and is not applicable for all type of business processes. More research should be conducted to investigate this assumption for each type of industry or sector (Antony, 2004a; Banuelas and Antony, 2004). The relationship between cost of quality and the annual sales turnover of the company, proposed by Mikel Harry (as cited in Pande *et al* (2000)) should be revisited. As stated by Mikel Harry, company operating at 3σ quality level will lose 25-40% of sales turnover because of cost of poor quality (COPQ). Again this figure was derived by research based on his initial research in Motorola, GE and other large manufacturing firm in USA. The same assumption is not applicable for service industry or for small businesses.

There is a paucity of literature on Six Sigma Project Selection, a topic that goes unnoticed in most organisations, and different techniques or methodologies that can be used for project selection, e.g. Analytical Hierarchy Process (AHP), Pugh Matrix, Failure Mode and Effect Analysis (FMEA), Project Prioritization Matrix, Fuzzy Logic, etc. The results from the informal poll conducted by Pande *et al* (2000) identified project selection as the most critical and most commonly mishandled activity in launching Six Sigma. This is another area which needs an immediate focus for continued development of Six Sigma.

To prevent Six Sigma from becoming commercial tools in the pockets of few consultants, it is imperative to develop a Six Sigma body of knowledge forum that can define the guidelines and standardise the procedures in the certification process of Black Belts and Green Belts. Currently, many consulting companies are offering Six Sigma Black Belt certification without any stringent requirement of conducting a Black Belt projects. There is a huge variation in the number of days of training for a typical Black Belt program (normally 20 days or 4 weeks of training is required to be a Black Belt). Consultants are offering 5-10 days of training (e.g. www.hutchins.co.uk, www.siliconbeachtraining.co.uk, www.expertrating.com, to name a few), using a cutting corner approach, to train a Black Belt. Six Sigma requires some heavy initial investment to train Black Belts for executing projects. This limits SMEs from embarking on Six Sigma journey due to resource constraints problem. Situation would be worse in SME if a Black Belt leaves the job after becoming certified. It is thus imperative to develop a organizational infrastructure for SMEs customized to the needs of SMEs. The need of Black Belt in a SME environment requires further investigation.

Six Sigma had gained momentum in the industry due to its practical approach to problem solving and alignment to financial savings (Schroeder *et al*., 2008). However from theoretical perspective, very limited research had focused on developing the underlying theory or definition of Six Sigma and measuring its impact on quality management theory and application (Schroeder *et al*., 2008; Linderman *et al*., 2003, 2006). Linderman *et al* (2003, 2006) were among the very few researchers to raise the issues of theoretical gap in Six Sigma research and proposed a goal-theoretic approach for strategic Six Sigma. This leads to criticism that Six Sigma is repacking of the traditional quality management practices (Zu *et al,* 2008).

Here, academia can play a critical role in bridging the gap existing between the theory and practice of Six Sigma (Linderman *et al*., 2003; Antony, 2004a; Mitra, 2004; Zu *et al,* 2008; Schroeder *et al*., 2008; Kumar *et al*., 2008; Antony, 2008a). It has been observed that very few universities in UK and rest of Europe are engaged in teaching and research on Six Sigma (Antony, 2004; Antony, 2008a). This needs to be changed in the future so that collaborative Six Sigma projects between the academic and industrial world must be established in both engineering and business schools. Six Sigma has made a huge impact on the industrial world, but its impact on the academic community is limited. It will therefore be incumbent on academic fraternity to carry out well- grounded research to explain the phenomena of Six Sigma. The academic world has indeed a crucial role to play to bridge the gap between the theory and practice of Six Sigma and to improve the existing methodology of Six Sigma (Antony, 2008a).

The role of Six Sigma in promoting the concept of statistical thinking for both engineers and business leaders is imperative, which is lacking at the moment (Hare, 2005). Statistical thinking – consisting of core principles such as process, variation and data – may be used to create a culture that should be deeply embedded in every employee within any organisation embarking on Six Sigma. A brief overview on agenda for future research in Six Sigma is presented in figure 3.4.

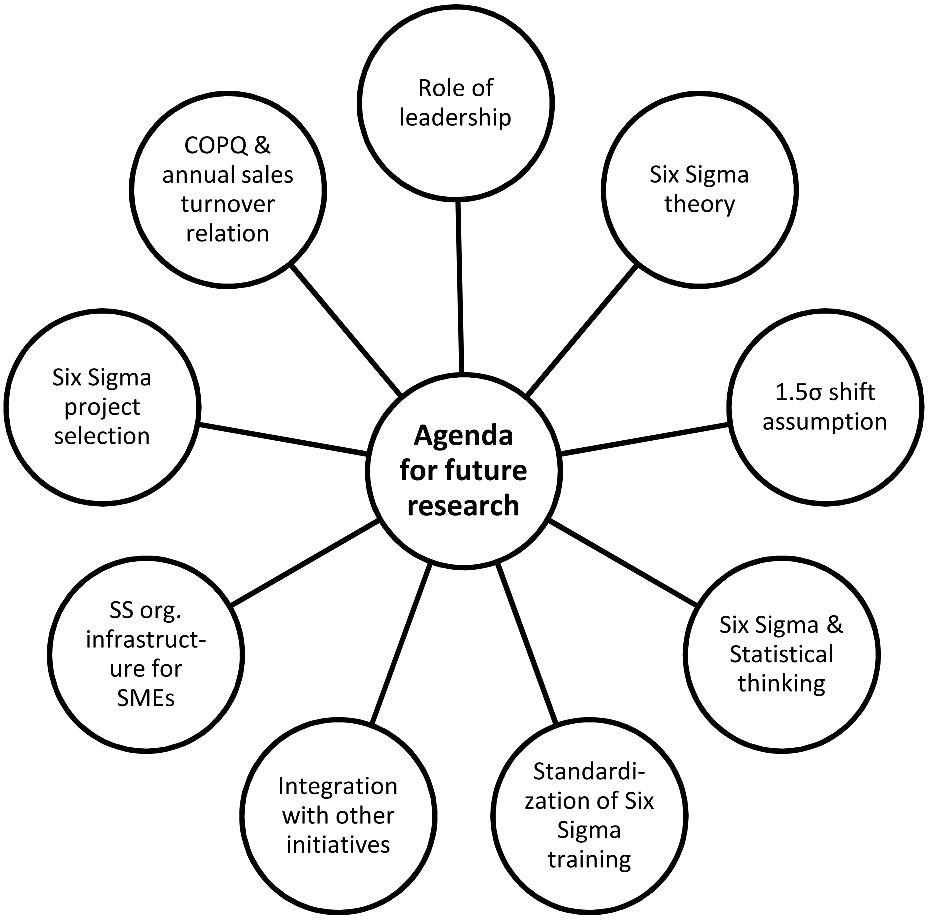

Figure 3.4: Agenda for future research in Six Sigma

Due to scant literature on Six Sigma in SMEs, author decided to explore articles published on implementation of continuous improvement initiatives like TQM, and Lean or certification system like ISO 9000 in SME environment. The author had followed the work of Ghobadian and Gallear (1996, 1997) and Yusof and Aspinwall (1999, 2000 a, b, c) throughout the doctoral research as they were among the few authors that conducted longitudinal study in the late 1990s on TQM implementation in the UK SMEs (similar to author's research topic on Six Sigma implementation in the UK SMEs). Extensive review of key articles facilitated in better understanding of quality management practices in SMEs and identified frameworks and models of CI proposed for and used by SMEs. Firstly, the scant literature on Six Sigma application in SMEs was reviewed followed by reviewing literature on quality management practices in SMEs based on implementation of TQM, Lean or ISO 9000 in SMEs.

3.3. Six Sigma in SMEs- A review of Literature

The literature depicts that Six Sigma has been implemented with success in many large corporations, but there is still less documented evidence of its implementation in smaller organisations. This section reviews few articles published on Six Sigma application in SMEs and gauge whether it has been introduced as a strategic change initiative in SMEs or used as an operational methodology for improving process efficiency.

Wessel and Burcher (2004) in their study identified the specific requirements for implementation of Six Sigma in German SMEs. This study also examined how Six Sigma needs modification to be applicable and valuable in a SME environment. This was the first survey study of its kind to be carried out on Six Sigma in SMEs. The study identified the lack of quality management system in majority of SMEs and only 15% of the firms were aware of Six Sigma initiative. The findings suggested to emphasise on the following key issues- quantification of financial savings from every single project; tracking of benefits realised from core projects over a period of time say 12 months; customized Six Sigma training program including full day awareness training for all employees; cultural change plan designed in advance and process management principles to be incorporated in Six Sigma program; and role of consultants in providing training and modular services to SMEs.

Another cross-sectional study was conducted by Antony *et al* (2005, 2008) to assess the current status of Six Sigma implementation in the UK SMEs. The results of the study showed that many SMEs were not aware of Six Sigma or had the resources to implement Six Sigma projects. Management involvement and participation, linking Six Sigma to customers and linking Six Sigma to business strategy were the most critical factors cited for the successful deployment of Six Sigma in SMEs. This paper had surveyed the use of Six Sigma in SMEs and showed that those who adopt it have reaped benefit both at strategic and operational level. If these benefits were to increase, there needs to be greater dissemination of its benefits and the creation of user groups that support SMEs in sharing and exchanging experiences of successful deployment of Six Sigma, thus promoting the best-in-class practice within the user group.

A pilot case study was conducted by author during his Master program on Six Sigma implementation in a local SME using a case study based approach (Kumar, 2007). Questionnaire was designed and adapted from Antony *et al* (2005) study and distributed to employees working in the firm. The CSFs study showed that management involvement and commitment was the most important factor in successful deployment of Six Sigma. Survey result depicted that the lack of resources and poor training/coaching are the two most important impeding factors in the successful deployment of Six Sigma. The information gathered from the interview showed that lack of commitment from the middle managers towards Six Sigma program was considered as the main pitfall in the implementation process. Employees need to be empowered to use the quality tools/techniques in their job and provided with requisite training to apply the knowledge in the right way.

Many SMEs implemented Six Sigma at an operational level and used it as a methodology to resolve complex problems on the shop-floor (Silen, 2000; Darshak and Desai, 2004; Desai, 2006; Thomas and Barton, 2006; Gupta and Schultz, 2005). Silen (2000) illustrated through a deployment of DMAIC model in a Finnish company, the real benefits of implementing Six Sigma. The significance of the voice of the customer and the commitment of top management as well as many other key-points were introduced to activate and help the deployment of Six Sigma in the company. A case study presented by Gupta and Schultz (2005) showed the benefits that an SME can gain through successful implementation of Six Sigma. The company located in US, achieved 30% improvement in on-time deliveries; 25% improvement in labour efficiencies; and 5 % improvement in profits per year by successfully deploying Six Sigma.

Darshak and Desai (2004) and Desai (2006) discussed the real life case where Six Sigma was successfully applied at a small scale firm in India to improve one of the core processes. The company was struggling with the increasing failures to meet customer delivery dates. The implementation of DMAIC methodology resulted in understanding the problem from all facets and laying out improvement through effective analysis of the roots of the problem. A case study on Six Sigma implementation in the UK manufacturing SME revealed the cost-effective way of eliminating the critical-to-quality issue (Thomas and Barton, 2006). Researchers identified the approach employed, tools and techniques used, improvement achieved in terms of cost and quality and thus the savings generated from Six Sigma implementation. An experimental design study was undertaken in order to identify the optimum parameter settings for the concerned process. The application of the Six Sigma approach achieved savings in excess of £60,000 for an initial outlay of less than £5000 in experimental and project costs.

In all the aforementioned case studies, Six Sigma was applied only for resolving some complex problems and was not introduced at a company-wide level. The real benefit may be realised by SMEs if it was incrementally implemented across the business areas. Other scant literature available on Six Sigma in SMEs was rather conceptual or viewpoint article and lacked demonstration of research rigour through conducting empirical / longitudinal research on the topic. Researchers and practitioners have provided their viewpoints, based on their experience, on critical success factors of Six Sigma or proposed a model/ framework/ step-by-step approach for implementing Six Sigma in SMEs. A summary of their key findings were presented below.

Strong leadership and senior management commitment was identified as critical to the success of Six Sigma program in SMEs (Antony *et al*, 2005, 2008; Kumar, 2007; Tennant, 2001; Adams *et al*., 2003; Waxer, 2004; Spanyi and Wurtzel, 2003). In small companies, the top management team need to be visibly supportive of every aspect of Six Sigma initiative and they must demonstrate by their active participation, involvement and by their actions that such support was more than lip service. Other critical success factors proposed were customer focus, communication, cultural change, education and training, reward and recognition, shared understanding of core business processes, resource commitment, understanding of Six Sigma methodology; and project prioritization and selection (Antony *et al*., 2005, 2008; Kumar, 2007; Spanyi and Wurtzel, 2003; Waxer, 2004)

Resource constraint was identified as an important issue by researcher to implement Six Sigma in a SME environment (Antony *et al*., 2005, 2008; Kumar, 2007; Waxer, 2004). Several alternatives were proposed to tackle the issue of resource constraints such as use of incremental approach to implement Six Sigma in core business processes (Kullmann, 2002) and limiting the training to Green Belt level (Gnibus and Krull, 2003); Black Belt not required in SME environment (Rowlands, 2004)- training more employees at Yellow Belt level to implement Six Sigma at a less cost and more manageable pace approach (Davis, 2003); Harry and Crawford (2004) proposed a new White Belt system to achieve quicker return on investment from Six Sigma- a white belt will execute 12 projects in a year with potential savings of $12000 expected from each project; and use of Porter's value chain and five forces model along with Six Sigma to provide strategic alignment, identifying training needs as well as prioritising Six Sigma projects for execution (Rowlands, 2004).

Although there are "start-up" costs to the deployment including training, leadership alignment and customer focus, a properly designed and deployed Six Sigma program should provide ample cost benefits rather quickly, even for smaller companies (Keller, 2003; Wilson, 2004). Keller argues that Six Sigma offers many SMEs the same benefits as larger companies: an improved bottom line. As many SMEs operate their business processes at the '*2 to 3 sigma quality level'*, an improvement of even 1 sigma represents a huge step in improving customer satisfaction and reducing costs (Spanyi and Wurtzel, 2003). For instance, if a customer order fulfilment process is operating at 3 sigma quality level (i.e., 66, 800 defects per million opportunities) and if we improve the sigma quality level to 4 sigma quality level (i.e., 6210 defects per million opportunities), then this process would realise a 10-fold improvement in performance. Assume each error or mistake cost $5 to fix (on average), the resulting cost savings would be in the range of $300,000 (Kumar, 2007).

Researchers also proposed frameworks and models to facilitate Six Sigma implementation in SMEs. All the models were based on the experience of researcher and lacked theoretical underpinning while designing the model. None of the models proposed below took into account the resource constraints factor and suggestion on how to implement Six Sigma. The practical application of models / frameworks in SME environment was not reported or published in the literature.

Schwinn (2003) proposed a new approach named Six Sigma Simplified (S3) tailored for small organisation for an entry into the world of Six Sigma. The S3 approach focuses on the following:

- Recognizes the need to be clear about values and assumptions.
- Recognizes that a Six Sigma approach is not always the best approach
- Starting small and minimizing the initial investment make sense
- Explicitly recognizes that a Six Sigma effort can focus on the revenue side of the organization, as well as the cost side.

- Explicitly recognizes that any kind or size of organization or community can benefit from Six Sigma.

Process Quality Associates (PQA), a Six Sigma and Quality Engineering training and consulting service provider proposed a practical framework for implementation of Six Sigma in SMEs (Process Quality Associates, 2005). To make the framework more applicable and suitable for SMEs, the company had developed a set of CSFs, which have been integrated into each phase of the Six Sigma methodology. Burton (2004) proposed alternative Six Sigma deployment model that allowed SMEs to implement Six Sigma at a pace where they can digest the methodology and achieve benefits, without significant resource commitment and overhead structure of the traditional Six Sigma. As a result, SMEs are sometimes able to achieve faster and more impressive benefits than their large customers. He also recommended an 8-step methodology for successful deployment of Six Sigma within SMEs.

3.4. Quality Management Practices in SMEs

The last fifteen years have witnessed increased focus on CI implementation in SMEs due to their increased contribution to national economy. Many success stories of TQM implementation in large organizations have been published in journals, magazines, and conferences with little focus on smaller firms leading to conclusions that TQM and the benefit it has to offer is applicable only for large businesses (Goh and Ridgway, 1994; Shea and Gobeli, 1995). Investigating the impact of size of the organization on TQM practices and performance, it was reported that larger firms derive greater benefits from TQM implementation than SMEs (Fisher, 1993; Powell, 1995; Terziovski and Samson, 2000; Garvin, 1988). The reasons for the same were attributed to long-term resource commitment and mature appreciation of TQM philosophy by senior managers in large firms (Fisher, 1993; Terziovski and Samson, 2000). Managers in SMEs expected immediate benefits from TQM and also struggled to allocate resources to facilitate implementation process.

In order to discover how organisation perception about TQM had changed between 1992 and1994, Witcher (1994) in collaboration with Scottish Enterprise and Scottish Quality Network conducted a survey in Scottish companies that included both large organisations and SMEs. A substantial slice of Scotland's commercial life was covered. The result of the study showed that TQM is most established in manufacturing and large organisations. It is least established in the public sector, services and SMEs. The main difficulties in implementing TQM were found to be entrenched attitudes, keeping TQM going, a lack of understanding, poor resources and leadership commitment.

Parkin and Parkin (1996) study indicated high awareness and adoption of TQM within British SMEs as compared to UK based Japanese-owned firms. Most of the SMEs struggled to have established formal procedures and systems such as BS5750 in place. The biggest challenge faced by SMEs to implement TQM lies in the translation of management strategies into employee action. Conducting case studies in 10 SMEs on their experience of implementing TQM, Shea and Gobeli (1995) highlighted the reasons as why SMEs embarked on TQM journey- to expand the business growth and for marketing purpose; consistent with management style supporting QM; changing customer expectations; employees focus; and improving poor performance of the company. Employees were proactive in the TQM firms to prevent the errors from occurring rather than taking action after the errors were detected.

Davig *et al*. (2003) conducted a survey of small manufacturing companies in Kentucky, USA and the results of the study showed that firms were slow to embrace the philosophy and practice of TQM. The main reason for this reluctance by smaller firms seemed to be a lack of understanding of TQM by top management. Even the firms implementing new quality programs in this study felt they were costly endeavours. They simply did not believe in the concept of "*quality is free*".

Anderson and Sohal (1999) investigated into TQM practices of Australian SMEs using Australian Quality Awards (AQA) criteria and measured its impact on firms performance. Leadership, strong customer focus, quality system, and good information management had greatest influence on performance of the company. The emphasis on data collection and measurement and its importance to meet customer expectations was highlighted by SMEs. Contrasting result was reported by Goh and Ridgway (1994) study, where only two out of thirty participating firms (majority of SMEs implementing BS5750 and only few thing of embarking on TQM journey) captured voice of customer and majority of them relied on customer complaints/compliments to assess customer satisfaction and their future requirements and expectations. Very limited training was provided to employees in direct touch with customers.

Lee (2004) carried out an exploratory study in small Chinese manufacturing firms to investigate the present status of TQM and its perception and development in these small firms. It was revealed from the study that even though TQM programs were well recognised by Chinese small firms and are willing to employ new advanced system and technologies, their organizational structure remained traditional. Lin *et al*. (1999) accessed the relationship between organizational climate and quality management practices of Taiwanese SMEs. It was found that SMEs that tend to de-emphasize organizational structure appear to have high-quality tendency. The study also affirmed that high-quality tendency groups as well as low-quality-tendency groups responded differently to organizational structure and organizational climate variables.

Management in small firms lacks theoretical knowledge on application of statistical tools to resolve problems and fear of statistics was restraining them from embracing tools and techniques that can have significant affect on SMEs performance (Thomas *et al*., 2009; Sousa *et al*., 2005, 2006; Spencer and Loomba, 2001; Davig *et al*., 2003). Sousa *et al* (2005, 2006) study reported very little understanding on the usage of tools and techniques of CI such as SPC; graphs, process flowcharts, and check sheets were most commonly used tools in SMEs; control charts and scatter plots were absent from the mostly used tools category. Employees had low skills to identify, select, and use quality tools to improve process efficiency. It gives an indication that SMEs awareness of benefits of tools & techniques of CI or cultural change program like TQM and Six Sigma is very limited. Manufacturing quality, price, product reliability, and product customization were frequently used criteria in SMEs to win new orders (Sousa *et al* 2005, 2006).

Spencer and Loomba (2001) examined the TQM practices employed by the smaller manufacturing firms in American Industries. Survey results indicated that SMEs focused on controlling the process with limited use of quality tools and techniques for problem solving, while non-production process receiving least attention for quality improvement. Similar findings was reported by Davig *et al*. (2003) that showed small firms in US were slow to embrace the philosophy and practice of TQM and its tools and techniques.

On the contrary, McAdam and Kelly (2002) study showed a good application of generic benchmarking technique in SMEs (already applying business excellence model [BEM]). The findings indicated the usefulness of benchmarking in increasing the rate of improvement of their quality initiatives. Researchers suggested the use of BEM as a foundation to utilize generic benchmarking in SME, which would further lead to successful learning and continuous improvement. Generic benchmarking can help SMEs identify strategic development needs and opportunities by getting feedback from benchmarking organizations involved, which may have otherwise remained unnoticed. Goh and Ridgway (1994) study reported minimal knowledge and use of benchmarking in SMEs. Benchmarking with their competitors was not practised in majority of the SMEs, which again showed their lack of commitment to CI.

In spite of the tangible benefits from TQM implementation in SMEs, very few firms were adhering to complete philosophy of TQM (Shea and Gobeli, 1995; Spencer and Loomba, 2001). SMEs struggled to perceive TQM as a philosophy and focus more on applying tools and techniques for resolving problems at the shop-floor level. The main reasons for TQM failure in Noci (1995) study were the result of lack of skilled employees, financial resources, effective decision making tools, and lack of specific goals in SMEs. Some of the reasons for less popularity of TQM implementation in SMEs were (Wilkes and Dale, 1998) – ambiguity in the definition of TQM and principles underpinning it not explained in the language which SMEs can understand; many SMEs not introduced to the concept of TQM or know the efficacy of approach. The challenge lies in integrating TQM philosophy into organizational strategic policy, which is complex process. It was believed that TQM failure in many organizations was the result of bad implementation strategies and processes (Hansson and Klefsjo, 2003).

Prajogo and Brown (2006) identified the decline in TQM implementation within SMEs due to lost popularity of initiative among Australian organizations after 1998. The reasons were attributed to lack of clarity of concept and benefit from the initiative, no pressure on SMEs or not driven by external parties, comfortable with informal QM practices and not preferring to adhere to any formal approach to CI, and publicity given to TQM failure.

The decline in the use of TQM in SMEs led author to investigate into the effectiveness of Six Sigma within SMEs environment and compare the quality management practices in Six Sigma SMEs against non-Six Sigma SMEs. This resulted in the emergence of following research question that required further investigation.

RQ2: *What are the critical differences in quality management practices of Six Sigma and non-Six Sigma SMEs?*

The next section was included to assess the role and impact of ISO 9000 on CI initiatives like Lean and Six Sigma. This was not the focus of study at the start of research. The results from the first phase of study indicated a pattern emerging from the response of 64 SMEs – ISO acting as a building block to facilitate Six Sigma implementation. This led author to review past literature on the role of ISO in facilitating TQM implementation.

3.4.1. ISO 9000 certification – Is it useful for SME? : An overview

ISO 9000 standard is another stream of quality management referring to series of standards for quality management system [QMS] (Sun and Cheng, 2002). ISO was officially formed in 1987 with delegates from 25 countries to facilitate international co-ordination and unification of industrial standards. There had been considerable growth in the number of ISO 9000 series certificates held by organizations. In 1999, there were 226, 349 companies worldwide holding ISO 9000 certifications (Wiele *et al*., 2000, 2001). The revised version of ISO 9000:1994, which was *ISO 9001:2000* (and now ISO 9001: 2008) focused more on CI based on PDCA improvement cycle of TQM and incorporated eight quality management principles aligned to the principles of TQM (Sun *et al*., 2004) – Leadership, people involvement, process approach, system approach to management, continual improvement, factual approach to decision making, mutually beneficial supplier relationship (www.iso.org). The ISO document clearly states minimal differences in 2008 version from 2000 version. ISO9001: 2008 had been made simpler in language, easy to use, readily translatable, and compatible with other management systems such as ISO 14001 (www.iso.org). This section limits the discussion to ISO 9001: 2000 as author struggled to find any published peer reviewed journal article on ISO 9001: 2008 certification by SMEs.

The main reasons for certification, as identified from literature, were driven by external need of improving market image or pressure from competitor/customer to force strategic change (Nwankwo, 2000; North *et* al., 1998; Quazi and Padibjo, 1998; Yusof and Aspinwall, 2000a, b; Chittenden *et al*., 1996; McTeer and Dale, 1994, 1996; Raynor and Porter, 1991; Mo and Chan, 1997; Noci, 1996; Lee and Oakes, 1995; Terziovski *et al*., 1997; Brown *et* al., 1998; Lee and Palmer, 1999; Sun and Cheng, 2002; Poksinska *et al*., 2006). For many SMEs, QMS was perceived as a tool for keeping and updating documentation and not a tool for managing organizational processes (Poksinska *et al*., 2006). Organization with this focus would struggle to realize improvement in product quality or market share. The real impact of such system could only be measured if the management removed the impediments of clear strategic intent, leadership commitment, supportive organizational arrangement (Raynor and Porter, 1991; Brown *et al*, 1998).

Achieving ISO certification does not mean that an organization has a culture driven by quality principles. Nwankwo (2000) statement clearly reflects on the aforementioned sentence- "*The main concern about the registration is metaphorically similar to passing school exam- the result obtained may not be able to differentiate between those who truly learned something and those who merely passed the exam by cramming*". Quality assurance system such as ISO 9000 does not guarantee product quality, still majority of SMEs see it as a destination to quality and end in itself (Goh and Ridgway, 1994; Meegan and Taylor, 1998; Wiele and Brown, 1997; Wiele *et* al., 2000; Seddon, 2000; Sun *et al*., 2004; Nwankwo, 2000). Thomas and Webb (2003) study showed little evidence of enhanced quality products or improved effectiveness of the internal operating structure through the implementation of formal quality systems. SMEs also found minimal improvement in productivity, costs, wastage rate, staff motivation, and staff retention as the result of certification (Wiele and Brown, 1997; Brown *et al*., 1998).

Other school of thoughts perceived improvement in product and service quality as a result of ISO certification (Sun, 1999, 2000; McAdam and McKeown, 1999; Kanji 1998). If a company had religiously followed the basic principle of ISO 9000 and developed procedures as prescribed in the standard, there was no need for certification [provided there is no pressure from key customers](McTeer and Dale, 1996). Stated by Yusof and Aspinwall (2000b) and supported by the findings of this study – "*Companies do not have to attain ISO 9000 certification if they fully understand the true nature of a good quality assurance system*".

Typical characteristics of organizations that see certification as an opportunity to improve internal processes were involvement and commitment of employees in developing ISO into workable system, improved management control, raised quality awareness among employees, improved awareness of problems within organizations, and improved product and service quality (Wiele and Brown, 1997; Brown *et al*., 1998; Terziovski *et al*., 1997). SMEs with this type of approach were likely to embark successfully on the TQM journey. It is imperative to note here that benefits realised from system was derived from the way of implementation and its operation rather than from standard itself (Poksinska *et al*., 2006).

The drawback of ISO 9000 lies in the amount of paperwork and cost of getting and maintaining certification (Goh and Ridgway, 1994; McTeer and Dale, 1996; Yusof and Aspinwall, 2000b; Mo and Chan, 1997; Wiele and Brown, 1997; Brown *et al*., 1998; Poksinska *et al*., 2006), increased labour and overhead costs, increased supervision, and reduced flexibility (Chittenden *et al*., 1996). Nwankwo (2000) proved that the long-term benefits from ISO 9000 for small companies may not be very important because of their poor, passive motives for certification, and a lack of true awareness about the standards and their potential. One of the reasons of failure of ISO 9000 or other formal quality systems in SMEs was due to its application in multitude of different ways resulting in significant variations in results and effectiveness experienced by SMEs (Thomas and Webb, 2003).

ISO 9000 had helped SMEs to develop, map and standardise their business processes; facilitate employees to understand their business processes and get better trained to be responsible for their own processes (McTeer and Dale, 1996); retaining the business contract, fewer customer complaints, and increasing market share (Chittenden *et al*., 1996). ISO is now observed as a vehicle for CI rather than simply administrative and bureaucratic procedures (Mulhaney *et al.,* 2004). Reflecting on the usefulness of ISO 9000 registration, Ghobadian and Gallear (1997) stated that accreditation to system such as BS5750 (UK standard) or ISO 9000 facilitated SMEs in the process of implementing TQM as it helped the participating firms in standardization and documentation of common procedures and records. The evidence was provided in the supporting statement from one case study firm- "*Management saw BS5750 as the best route of putting in place the required basic formal* *procedures......................., it was felt BS5750 provided a good foundation from which to launch TQM*".

Soltani and Lai (2007) conducted survey in 150 EFQM organizations (including both SMEs and large organizations) in UK to indicate on ISO being foundation or precursor for TQM success. Finding was also consistent with prior researchers, talking about organizations moving beyond ISO (Taormina, 2002; Terziovski *et al*., 1997; Taylor, 1995; Russell, 2000; Coleman and Douglas, 2003; Kanji, 1998; Goh and Ridgway, 1994; Taylor, 1995; Ghobadian and Gallear, 1996, 1997; McTeer and Dale, 1996; Quazi and Padibjo, 1998; Yusof and Aspinwall, 2000b; Gotzamani, 2004; Lewis *et al*., 2006). Research had demonstrated the benefit of ISO certification before implementing TQM - degree of standardization and procedural control; employees trained to manage and control their process; establishing metrics for processes and collecting data for measurement. Strict adherence to ISO guidelines prepares the employees culturally to support the creation of TQM environment (Dale et al., 2007; Dale and Boaden, 1993).

Some researchers also reported the limited understanding of SME on the relationship between ISO registration and TQM implementation (McTeer and Dale, 1994; Lee and Palmer, 1999). SMEs tend to implement only minimum requirements necessary for ISO 9000 certification, with a little intention to extend their quality programmes further (McTeer and Dale, 1994; Lee and Palmer, 1999; Williams, 1997). Too much focus on financial performance measures, measuring customer satisfaction through customer complaints, and lack of understanding of process of CI by top management were identified as major obstacle for ISO certified SMEs to progress towards TQM implementation. Wiele and Brown (1997) also observed that very few SMEs moved beyond certification to implement initiatives like TQM. SMEs also failed to have an integrated performance measures at all levels in the organization that can promote proactive approach to pursuing goals of TQM. On the other hand, Sun and Cheng (2002) findings from Norwegian SMEs indicated of significant relationship between ISO certification and TQM practices / business performance.

Research had identified important factors for the successful implementation of ISO 9000 standards in SMEs: attitude of employees to certification system (i.e. focus on to improve organisational performance or to satisfy external pressure), understanding and knowledge about QMS, top management commitment, employees' commitment and internal communication, way the companies are using external help, the degree of education prior to certification, development of fairly detailed plans for the implementation, and documentation being adapted to the organisation and not to the standard (Quazi and Padibjo, 1998; Gustafsson *et al* 2001; Gotzamani and Tsiotras 2002; Poksinska *et al*., 2006). Other critical factors for ISO success was identified from Briscoe *et al* (2005) study – inculcating quality culture, breaking stumbling blocks to ISO adoption, readiness assessment for ISO adoption; making ISO practices a part of SME's quality routine. Government role in supporting quality movement in Singapore SMEs was vital in their progression from ISO 9000 towards TQM (Quazi and Padibjo, 1998).

A brief overview of the entire discussion was presented in table 3.2.

Table 3.2: Motivation, CSFs, impediments, and benefits of ISO 9000 certification

Motivation	CSFs	Impediments	Impact / Effects	
			Positive	*Negative*
Driven by external need[a] - to improve market image - pressure from competitor/customer *Precursor to TQM*[b]	- Understanding of QMS by top mgmt.[c,d] - Top Mgmt commitment[c,d] - Government role[d] - Employee's attitude and commitment towards QMS[c] - Existence of quality culture[e] - Education and training[c]	- Resource constraints[f] - Too Costly[f] - Lack of top mgmt. Commitment[g] - Lack of knowledge about QMS[f,g] - Lack of strategic focus[g]	*Internal Benefits*[b,h]: -standard systems and procedures documented - increased quality awareness - better management control -Improved product quality *External Benefits*[a]: -improved image - marketing tool	- Increased paper work[f] - Minimal improvement in product quality[i] - Increased cost[f] - ISO considered as destination to quality journey[i] - staff motivation[f,g]

Sources: [a] Nwankwo (2000), North *et* al (1998),Yusof & Aspinwall (2000a,b),Chittenden *et al*(1996), McTeer & Dale(1994,1996), Noci(1996), Lee & Oakes (1995), Terziovski *et al* (1997), Brown *et al* (1998), Poksinska *et al* (2006); [b] Taylor (1995), Ghobadian & Gallear (1997), McTeer & Dale (1996), Yusof & Aspinwall (2000b), Gotzamani(2004), Lewis *et al* (2006);[c] Gustafsson *et al* (2001), Gotzamani and Tsiotras (2002), Poksinska *et al* (2006); [d] Quazi and Padibjo(1998); [e] Briscoe *et al* (2005);[f] Wiele & Brown(1997), Brown *et al*(1998); [g] Gotzamani (2004),Lewis *et al* (2006);[h] Huarng(1998),McTeer and Dale (1994); [i] Goh and Ridgway (1994), Meegan and Taylor (1998), Wiele and Brown (1997), Seddon (2000), Sun *et al* (2004), Nwankwo (2000)

The aforementioned review leaves many questions about certification unanswered: for example, Is ISO precursor to TQM / Six Sigma implementation?; Do SMEs need certification before embarking on Six Sigma?; What is the impact of certification on the performance of SMEs?. These questions were briefly explored in the second phase of research, when author conducted multiple case studies in the UK manufacturing SMEs.

3.5. Critical Success Factors and Challenges to implementation

In chapter 2, author discussed about the CSFs and key challenges faced by Small businesses during its life cycle. Some of the commonality was observed in the CSFs of small business growth and that of CI initiatives in SMEs (refer to Section 2.4 and 2.5 for more information). Ten CSFs were identified from the literature review process (including some key literature on CI initiatives in SMEs) and each factor was discussed in detail. CSFs discussion was also included while reviewing literature on ISO application in SMEs in Section 3.4.1 and models/ frameworks proposed by researchers in Section 3.7. To avoid repletion, this section briefly presents the key findings from the quality management literature in SMEs on CSFs and key challenges faced by SMEs during implementation of CI initiatives.

3.5.1. Critical Success Factors

The concept of identifying and applying CSFs to business problems is not a revolutionary new field of work (Caralli, 2004). It dates back to the original concept of *success factors*, as a basis for determining the information needs of managers, proposed by Daniel (1961) and popularized by Rockart (1979). CSFs are those factors which are critical to the success of any organisation, in the sense that, if objectives associated with the factors are not achieved, the organisation will fail - perhaps catastrophically so (Rockart, 1979). Oakland (2000, pg.26) defines CSFs as *".......a term used to mean the most important sub goals of a business or organization.........what must be accomplished for the mission to be achieved"*. In the context of Six Sigma project implementation, CSFs represent the essential ingredients without which a project stands little chance of success (Antony and Banuelas, 2002).

Leadership and top management commitment was identified as the most important core values of TQM to establish quality culture in organizations (Gunasekaran *et* al., 1996; Hansson and Klefsjo, 2003; Hellsten and Klefsjo, 2000; Bergman and Klefsjo, 2003 as cited in Hansson and Klefsjo (2003)). Leadership commitment was demonstrated by leading from the front, developing own understanding of CI initiatives, stimulating individual values, motivating employees, breaking down stumbling blocks and making resources available during change process. The flat structure of SMEs increased the natural visibility of involved managers, provided they are committed to TQM implementation, to the rest of the employees and motivated them to accept the change (McAdam, 2000). Leadership was an important constituent of excellence models as well as equally important for successful implementation of CI initiatives such as TQM or Six Sigma (McAdam, 2000; Gunasekaran *et al*., 1996; Lin, 1999; Taylor, 1997).

Goh and Ridgway (1994) identified five pillars required for TQM implementation in SMEs as management commitment, customer focus, quality costs, quality systems, and CI. Moreno-Luzon (1993) reported that SMEs successful in TQM implementation focused more on product and process innovation by having a motivated management team with better managing skills. SMEs lack skilled workforce as compared to large organization and thus implementation of TQM may help employees to get trained on the tools and techniques of CI.

To understand the specific needs of SMES, an important study was undertaken by Ghobadian and Gallear (1996, 1997), who assessed the requirements and characteristics of large corporations versus SMEs in the UK with regard to their advantages and disadvantages in terms of TQM. Ghobadian and Gallear (1996, 1997) identified unique advantages possessed by SMEs in terms of effective and open communication channels, low resistance to change, people orientation, company-wide awareness, functional integration, and innovativeness. However, SMEs face disadvantages in the continuous search for the improvement of the business with quality, productivity and cost reductions as indivisible elements, as well as process orientation, spending on training, and discipline about goals and standards. Similar findings were reported by researchers investigating CI initiatives in SMEs (Wiele and Brown, 1998; Yusof and Aspinwall, 2000 a, b; Shea and Gobeli, 1995; Gunasekaran *et al.* 1996). These factors were also cited by proponents of Six Sigma and Lean – they were in consensus on the role of leadership, top management commitment and a top-down approach for implementation of Six Sigma or Lean (e.g. Antony *et al*., 2005, 2008; Kumar, 2007; Achanga *et al*., 2006).

Lee (2004) carried out an exploratory study in small Chinese manufacturing firms to investigate the present status of TQM and its perception and development in these small firms. The survey result was in consensus with other researchers (Ahire and Golhar, 1996; Lee, 1998; Black and Porter, 1996; Yusof and Aspinwall, 1999, 2000a; Rahman, 2001 a,b) with respect to critical success factors for TQM implementation: Top management commitment; Employee Participation, supplier involvement; and training and education.

Researchers and practitioners have proposed frameworks or guidelines for Six Sigma deployment in SMEs (Spanyi and Wurtzel, 2003; Gupta and Schultz, 2005; Schwinn, 2003; Waxer, 2004; PQA, 2003; Andrews, 2004; Wessel and Burcher, 2004; Rowlands, 2004; Kumar, 2007; Antony *et al*., 2005, 2008). The following points may be taken into account for the successful deployment of Six Sigma in SMEs: Leadership and Management commitment; Organizational infrastructure; Cultural change; Education and training; Vision and plan statement; Linking Six Sigma to customer; Linking Six Sigma to business strategy; Linking Six Sigma to employees; Linking Six Sigma to suppliers; Communication; Understanding of Six Sigma; Project management skills; and Project prioritization and selection.

It is noteworthy that the aforementioned critical factors have global application to assist in the successful implementation of any major business initiatives, not just the Six Sigma program. The identification of success factors will encourage their consideration when companies are developing an appropriate implementation plan (Antony and Banuelas, 2002). If any of the critical success factors is missing during the development and implementation stages of a Six Sigma program, it would then be the difference between a successful implementation and a waste of resources, effort, time and money (Antony and Banuelas, 2002). The key findings on CSFs from the literature was summarised in table 3.3. It was clearly indicated from table 3.3 that leadership, management commitment, linking CI initiatives to employees, customers, and business strategy, education and training, existence of QMS and measurement system were considered critical to the success of CI initiatives in SMEs.

Table 3.3: Critical success factors of CI initiatives in SMEs

Critical Success Factors / Researchers	Kumar (2007)	Antony *et al* (2005,2008)	Wessel & Burcher (2004)	Yusof & Aspinwall (1999)	Ghobadian & Gallear (1996)	Achanga *et al* (2006)	Antony & Desai (2009)	Goh & Ridgway (1994)	Haksever (1996)	Spencer & Loomba (2001)	Shea & Gobeli (1995)	Lin (1999)	Lee (1998, 2004)	Rahman (2001a,b)	Sohail & Hoong (2003)	Ahire & Golhar (1996)	Tannock *et al* (2002)
Strong leadership				X	X	X	X		X	X	X			X			X
Senior management commitment	X	X		X	X	X	X	X	X		X	X	X		X	X	X
Communication	X	X			X											X	X
Linking CI initiatives to employee	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X
Cultural change	X	X	X		X	X	X										
Education & training	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X
Link CI initiatives to customer	X	X		X	X		X	X	X	X	X	X	X	X		X	X
Project selection	X	X					X										
Link CI initiatives to Business Strategy	X	X	X				X		X					X	X		X
Link CI initiatives to supplier	X	X		X	X		X			X			X			X	
Project management skill	X	X	X				X										
Organizational infrastructure	X	X		X			X		X			X					
Clear Vision & Plan	X					X			X								
IT & innovation											X			X			
Knowledge of CI & quality tools & techniques	X	X		X			X			X	X	X	X	X	X	X	X
Existence of measurement system			X	X	X			X	X	X	X		X		X		X
Existence of quality management system			X	X	X			X		X			X	X	X	X	X
Rewards & recognition			X						X		X						
Teamwork					X				X		X						
Availability of resources					X	X			X			X					

3.5.2. Challenges and Barriers to implementation of CI initiatives

The issue of whether quality management programs can be effectively utilised by SMEs remains uncertain (Husband, 1997). Common quality models, such as quality systems and certification, have been adopted by some SMEs, and yet the rate of implementation is lower than larger organisations (Kumar, 2007; Antony *et* al., 2005, 2008; Brown and Wiele, 1995; Husband, 1997; Terziovski *et al*, 1997; Ramsey, 1998). More holistic quality management initiatives, such as TQM, also appeared to exhibit low implementation rates (Ghobadian and Gallear, 1996; Van der Wiele and Brown, 1998). It was suspected that the poor adoption of quality management initiatives in SMEs is due to multiple and complex reasons, not just the often stated impediments of cost, time and relative impacts (Gome, 1996). In addition, it may be that the quality programs are being treated as an extension or separate components of a SME business operation.

Many CI initiatives programs like Six Sigma do not appear to be easily understood or interpreted by SMEs, which may be a significant contributor to low implementation. There is also evidence to suggest that quality management programs are not being taken up by SMEs for several reasons, viz:

- Difficult to distinguish between different quality programmes like Six Sigma, TQM, ISO, EFQM and the system that suits best to their needs. SMEs are unclear about the advantages (due to lack of knowledge) that one system has over other (Husband, 1997; Terziovski *et al*, 1997; Husband and Mandal, 1999; Yusof and Aspinwall, 1999; Kumar, 2007; Antony *et* al., 2008)
- SMEs believe that their existing culture and system, such as ISO 9000 is sufficient to meet their business needs (Andrews, 2004; Yusof and Aspinwall, 1999). Senior managers in SMEs view Quality System such as ISO 9000 as the destination of the achievement of quality (McTeer and Dale, 1994; Lee and Palmer, 1999; Wiele and Brown, 1997). In fact, quality improvement is always meant to be a journey rather than mere destination.
- There is very little evidence of success of Six Sigma in SMEs context. SMEs believe that this program is another fad, fantasy or flavour of the month like TQM and BPR (Smith *et al*., 1994; Andrews, 2004; Kumar, 2007; Antony *et* al., 2008)

- Lack of management commitment and their misinterpretation about the time and resources consumed for implementing Six Sigma inhibits the SMEs initiative (Andrews, 2004; Antony *et al*., 2005).
- SMEs blindly view Six Sigma or TQM as a panacea for all process and quality problems, and as a result they encounter failure in its implementation when applying to every problem (Andrews, 2004; Thomas and Webb, 2003)
- SMEs have a misconception that Six Sigma involves lots of statistics, which is beyond their domain (Kumar *et al*., 2008; Kumar, 2007; Andrews, 2004; Antony *et al*., 2005).

In Parkin and Parkin (1996) study, SMEs were struggling to realize the full potential of TQM due to failure in translating management strategies into employee action. Parkin and Parkin (1996) stated that SMEs are conversant of the benefits of TQM but were not willing or competent enough to implement it effectively across their organization. As cited by Ghobadian and Gallear (1997) – “.......*probably the biggest obstacle to the introduction of TQM in SMEs is the ‘management realization’ and the ability of owner managers to modify their behaviour and management style”.* Once the top management realizes the need for change, it is easier for SMEs to attain cultural change than in large organizations.

TQM perception varies with firm size and planning behaviour. This was validated by Temtime and Solomon (2002) based on survey results examining the relationships between TQM perceptions, planning behaviour (strategic and operational), and firm size in 57 SMEs within Ethiopia (East African Country). The findings indicate that excessive emphasis on short-term profitability, lack of resources, business planning and vision, and misperception of TQM practices were among the main obstacles in adoption of a formal TQM program.

Some of the typical barriers faced by small firms in implementation processes were:

- Lack of visible leadership (Ghobadian and Gallear, 1997)
- Lack of vision, strategies and overall objectives (Lee and Oakes, 1995; Moreno-Luzon, 1993)
- Lack of resources [human, financial, technical] (Moreno-Luzon, 1993; Lee and Oakes, 1995; Haksever, 1996; Ghobadian and Gallear, 1996; Yusof and Aspinwall, 2000b)

- Lack of managerial experience in quality management (Ghobadian and Gallear, 1996, 1997; Yusof and Aspinwall, 2000b)
- Focus on detection based system rather than prevention based approach (Moreno-Luzon, 1993; Ghobadian and Gallear, 1996)
- Focus on short term gains and objectives (Moreno-Luzon, 1993; Barrier, 1992)
- Trying to achieve too much in short-time (Yusof and Aspinwall, 2000b)
- Lack of involvement of non-production staff in quality improvement (Yusof and Aspinwall, 2000b)
- Lack of formal procedures before TQM implementation (Ghobadian and Gallear, 1996, 1997)
- Past history of failure of different change initiatives (Ghobadian and Gallear, 1996, 1997)
- The lack of bargaining power against suppliers and lack of resources are major hindrances encountered by them when implementing TQM programs (Lee, 2004).
- Failure to translate management strategies for TQM implementation into employees action (Parkin and Parkin, 1996)

Resource constraints were stated as a major barrier for SMEs to embark on any change initiatives such as TQM (Lee and Oakes, 1995; Haksever, 1996; Ghobadian and Gallear, 1996, 1997; Yusof and Aspinwall, 2000b, 2001; Antony *et al.*, 2008). This often impedes SMEs manager to allocate funds for training and development of employees or to send employees for external training (Moreno-Luzon, 1993; Lee and Oakes, 1995). Understanding of barriers faced during CI initiative implementation may facilitate in the development of an effective and practical framework for Six Sigma implementation.

Literature review on CSFs and challenges in implementing initiatives like TQM led to the emergence of third research question to identify the CSFs and challenges faced by the UK SMEs during Six Sigma implementation.

RQ3: *What are the critical success factors and barriers to implementation of Six Sigma in SMEs?*

3.6. Impact of CI initiative on Organizational Performance

Preceding sections focused on reviewing extant SMEs literature on quality management practices, CSFs and barriers to implementation of CI initiatives or ISO certification system and provided a useful understanding of the SMEs perception towards CI or certification system like ISO. This section emphasised on understanding the relationship between quality practices and organizational performance of SMEs through review of scant literature that empirically examines the aforementioned relationship.

In an effort to understand the usage of performance measurement system in UK and Portuguese SMEs, Sousa et al (2005, 2006) conducted a survey involving manufacturing and service SMEs in two countries. Findings reported from both studies matched with other literature

- Level of use of performance measurement (PM) very low in SMEs; more focus on financial measures; very limited focus on innovation and learning measure.
- Customer performance, employee training, delivery performance, and financial measures were the top 4 PM criteria used by SMEs; on-time delivery, in-process quality, unit production cost were the most important factors within PM criteria used in SMEs.
- Very little understanding on the usage of tools & techniques of CI such as SPC; graphs, process flowcharts, and check sheets were most commonly used tools in SMEs; control charts and scatter plots were absent from the mostly used tools category
- Training of employees, cost, information system currently used, and defining new performance measures were important obstacles to the adoption of new PM
- Employees have low skills to identify, select, use quality tools to improve process efficiency

Yusof and Aspinwall (2000b) proposed a conceptual framework tailored to the needs of SMEs for implementing TQM and four case studies were conducted to validate the proposed framework (Yusof and Aspinwall 2000c). The results of the study showed that companies embarking on any quality programme in the past perform better than those that have not embarked on any such programme. The results of the case study was supported by the findings of Ahmed and Hassan (2002) in Malaysian SMEs that revealed the firms implementing TQM exceeded in performance with respect to non-adopters of TQM.

A comparative analysis on the use of quality tools and techniques, management practices, training to employee, performance measures, etc, between firms implementing TQM and all the firms involved in survey was conducted by Ahmed and Hassan (2002). It was found the firms implementing TQM exceeded in performance with respect to each variable being used for comparison. Shea and Gobeli (1995) identified the benefits realised from TQM implementation in 10 case study SMEs such as increased customer satisfaction (internal & external), increased employees retention, and improved internal processes. Similar result was observed by Spencer and Loomba (2001) surveying the USA SMEs. TQM implementation had a positive impact on reduction of inventory, lead-time, operating costs, and labour costs.

Conflicting results were observed while understanding the impact of TQM on firms with and without ISO 9000 certification. Sohail and Hoong (2003) observed positive impact of TQM on performance of ISO certified firms as compared to non-certified firms. ISO certified firms adhered to TQM principles to certain extent, had established systems and procedures in place, applied tools of CI to some degree, and observed better organizational performance. Aforementioned findings were missing from the non-certified SMEs. On the contrary, Rahman (2001a) and Taylor and Wright (2003) study revealed no difference in performance of firms with and without certification. Contradictory findings may be the result of different geographical location of study or limited sample size for the project undertaken.

Length of TQM adoption had significant correlation with QM practices and performance as observed in Prajogo and Brown (2006) and Powell (1995) study. The findings were in consensus with Sohail and Hoong (2003) study on Malaysian SMEs. Researchers suggested that real benefits of TQM in SMEs can only be realised by long-term focus and commitment to initiatives. But the length of ISO adoption was identified to have negligible correlation with QM practices and performance (Prajogo and Brown, 2006; Rahman, 2001a,b; Taylor and Wright, 2003).

Rahman (2001a,b) made an attempt to identify the extent of TQM practices in SMEs in Western Australia and its impact on business performance. Data analysis showed significant multicollinearity among the parameter, which means that the bivariate correlations between the TQM (criteria) practices and organisational performance should be considered cautiously. From the survey result, it was inferred that management commitment, employee involvement, and customer focus are three important parameters affecting the organization performance in terms of revenue, number of customer and profitability.

To explore the actual impact of quality on small business, a number of small ISO 9000 businesses were surveyed in Northern Ireland by McAdam and McKeown (1999). The main conclusions and recommendations arising from the article were that small businesses can benefit from implementing TQM. However, small firms implementing TQM need to learn to be more externally focused, i.e. customer focused, to measure the financial impact of TQM on bottom line performance and to use direct methods to measure customer satisfaction. Overall, the research showed that small businesses in Northern Ireland have achieved benefits from both ISO 9000 and TQM. The majority of the businesses said that TQM was more beneficial than ISO 9000 and that both complemented one another.

Salaheldin (2008) studied the impact of CSFs of TQM (classified into strategic, tactical, and operational factors) on operational an organizational performance of Qatari SMEs. Strategic factors (including top management commitment, organizational culture, leadership, continuous improvement, quality goals and policy, resources value addition process and benchmarking) were identified critical in successful implementation of TQM in SMEs, matching with the viewpoints of other researchers (Powell, 1995; Samson and Terziovski, 1999; Brah *et al*, 2002). The findings also revealed the relationship, though partial, between TQM implementation and firm performance (both operational and organizational performance) and confirming to the findings of previous research (Demirbag *et al*., 2006 a,b; Sila, 2007; Rahman, 2001; Seth and Triparthi, 2005). Strategic factors had strong impact on both operational and organizational performance; tactical factors had strong impact on operational performance; operational factor had strong impact on both operational and organizational performance.

TQM practices were found to be partially correlated to quality performance in a survey conducted on Malaysian ISO 9000:2000 certified manufacturing organizations [including both small and large organizations] (Arumugam *et al*., 2008). Continual improvement and customer focus were critical and significantly affected quality performance of firms (Arumugam *et al*., 2008). Process management, information analysis, leadership, supplier relationship, quality system improvement, and people involvement had no significant influence on quality performance. Fact based decision making was identified as less prevalent in ISO 9001:2000 certified organizations. There was no comparison between small and large firms with respect to CSFs or performance to identify the similarity/differences in the two groups.

Demirbag *et al* (2006a) conducted survey in Turkey textile SMEs and used structured equation modelling to establish relationship between TQM implementation practices and organizational performance (including both financial and non-financial measures). Strong positive correlation was observed between non-financial measure and TQM implementation, while partial weak relationship established between financial measures and TQM implementation. In a similar study, Demirbag *et al* (2006b) tested relationship between TQM practices, market orientation (MO), and organizational performance. MO had a strong and positive relationship with TQM practices and strong relationship with performance through mediating role of TQM practices. Researchers suggested amalgamating MO with TQM practices to improve performance of manufacturing SMEs.

Ahire *et al* (1996) surveyed 500 companies in USA, implementing any form of quality system, to investigate into quality management practices in TQM and non-TQM firms. One third of the firm perceived very limited benefit and two-thirds of the TQM / quality system implementation program have failed to show any benefit and was ground to halt.

The relationship between TQM and organizational performance in SMEs has been discussed extensively in literature with mixed results. Researchers have established positive relationship between successful implementation of TQM and organizational performance (Moreno-Luzon, 1993; Zairi *et al*., 1994; Ahire and Golhar, 1996; Hendricks and Singhal, 1997; Hendricks and Singhal, 2001; Samson and Terziovski, 1999; Lee, 2004). Other school of thoughts have questioned the actual benefit of TQM implementation on organizational performance (Powell, 1995; Harari, 1997; Pyzdek, 1999; Antony *et al*., 2005; Struebing and Klaus, 1997). The reasons for less popularity of TQM implementation in SMEs or failure of TQM were attributed to ambiguity in the definition of TQM and principles underpinning it not explained in the language which SMEs can understand and inappropriate implementation strategies and processes (Wilkes and Dale, 1998). Also many SMEs were not introduced to the concept of TQM or know the efficacy of approach. Similar findings have been reported on failure of TQM initiatives in large organizations.

Summary of key findings from this section was presented in table 3.4. The aforementioned discussion leads to the emergence of following research questions to investigate in this doctoral research.

RQ4: *Does the performance of Six Sigma firms differ from non-Six Sigma firms?*

Table 3.4: A review of impact of CI initiatives on organizational performance

Author (Year), Country	Research Methodology used, response rate (%), type of participating firm	Quality Initiative(s) Focused on	Key Performance Indicators	Factors affecting performance	Impact of quality initiative on firm performance (FP)
Sohail & Hoong (2003), Malaysia	Survey, 20.2%, Mfg. & Service industry	TQM firms with & without ISO 9000 certification	Several items for 6 factors listed in next column included to measure performance	Customer Mgmt. & quality satisfaction; strategic planning; leadership; information availability; employee empowerment; organizational control & performance	ISO 9000 have +ve impact on FP as compared to non-certified SMEs
Rahman (2001a) Australia	Survey, 21%, Mfg. & Service industry	TQM firms with & without ISO 9000 certification	Revenue, profitability, number of customers	Process control was the only factor (out of 10 factors) that had higher mean rating for firms with ISO certification compared to non-certified firms	No significant differences b/w ISO9000 certified and non-certified SMEs w.r.t TQM implementation & performance
Rahman (2001b), Australia	Survey, 21%, Mfg. & Service industry	TQM	Revenue, profitability, number of customers	Leadership; Processes, products & services; People; Customer focus	4 factors +vely related to FP, though people & customer focus were found significant
Shea and Gobeli (1995), USA	Case Study, 10 sample firms, Mfg.+ Service + Non-profit SMEs	TQM	Customer satisfaction Employee satisfaction Productivity	Customer orientation; employee empowerment; continuous improvement (though less evidence of usage of data driven actions, quality tools & techniques, structured problem solving approach)	+ve impact in terms of customer and employees satisfaction, employee retention, & improvement in internal processes & performance

Spencer & Loomba (2001), USA	Survey, 34.22%, Mfg.	TQM	Inventory, lead times, labour costs, operating expenses	Employee involvement; quality leadership; TQM training; use of process improvement methods; customer focus; level of quality policies & measurement; and supplier programs *Still less use of problem solving methods evident in SMEs*	+ve impact of TQM on all the performance criteria
Anderson and Sohal (1999), Australia	Survey, 9.23%, Mfg.+ Service industry	Studying TQM effectiveness using Australian Quality Award (AQA) framework	*Organizational Performance included:* cost of production or service; quality of product or service; flexibility of delivery; timeliness of delivery, and productivity improvements *Business Performance included*: sales; market share, employment levels; cash flow; exports; and overall competitiveness	*Leadership practices* was most important factor; other factors such as *customer focus* and *quality practices* had limited influence on outcome; *people management, information & analysis, strategy & policy practices* had no influence on outcome	Impact of TQM on organizational performance was +ve; QM practices had highest impact on overall competitiveness and least on export
Terziovski and Samson (2000), Australia & New Zealand	Survey, over 32%, Mfg. Industry *Includes sample of both small and large firms*	TQM (focused on studying the impact of TQM w.r.t size of the firm)	14 Organizational performance variables included from MBNQA, AQA,EQA framework	*-Not discussed-* Size of the firms impedes TQM implementation with larger firms deriving greater benefits from TQM than SMEs	TQM is significantly & +vely related to- customer satisfaction, employee morale, on-time delivery, productivity, cashflow, and sales growth
Prajogo and Brown (2006), Australia	Survey, 22.8%, Mfg.+ Service industry	ISO 9000 & TQM	Product quality & productivity	Leadership; Strategic planning; customer focus; information & analysis; people management; process management.	Length of TQM adoption significantly & +vely correlated with QM practices & performance Length of ISO adoption had negligible

				All factors had an impact on performance though not tested statistically	correlation with QM practices & performance
Sousa *et al* (2005), Portugal	Survey, 19%, Mfg. + Service industry	TQM, Balance Scorecard, ISO, general quality practices	Productivity measures; quality performance measures; financial measures; employee training measures; measures of innovation; delivery performance measures; service measures; and other measures	*-Not discussed-* *Very limited knowledge & low usage of tools of CI such as SPC – may be attributed to low employees skills*	*Impact of QI on FP not discussed; focused on the existences of PM system in SMEs; On-time delivery, in-process quality, incoming parts quality* were the most cited measures used by SMEs
Sousa *et al* (2006), UK	Survey, 12%, Mfg. + Service industry	TQM, Balance Scorecard, ISO, general quality practices	Same as above *Level of use of PM very low due to lack of employees training, information system currently used & defining new PM*	*-Not discussed-* *Very limited knowledge & low usage of tools of CI such as SPC – may be attributed to low employees skills*	*Impact of QI on FP not discussed; focused on the existences of PM system in SMEs;* Financial measures more widely used; On-time delivery, in-process quality, & unit production cost most important measures used in SME

3.7. Quality Management Maturity Models and Frameworks– A Review

Goh and Ridgway (1994) emphasized on development of a cost-effective framework for TQM implementation in SMEs. The idea of cost-effective framework for SMEs was supported by other researchers as well (Yusof and Aspinwall, 2000c; Ghobadian and Gallear, 1997; Stuart and Husband, 1999; Thomas and Webb, 2003; Hansson and Klefsjo, 2003; McAdam, 2000; Antony et al., 2008). A sound implementation framework for Six Sigma implementation in SMEs may facilitate a transformation in culture from fire-fighting mode to a new culture of proactive approach, where decisions are based on data, constant plans are made, and continuous improvement becomes a daily norm. Moreover, it will provide a road map and direction for SMEs to implement Six Sigma in a more comprehensive, controlled and timely manner.

Before discussing framework for CI implementation in SMEs, it was equally important to first understand the preparedness of a SME to implement CI initiatives such as TQM or Six Sigma. If a SME is culturally ready to implement CI initiatives, than the customized frameworks and models proposed for SMEs are required to guide them through the implementation process. Researchers have proposed maturity models in the past for TQM implementation that assesses the stages or levels reached by an organization in their CI journey and evaluate its implication for organizational performance (Dale and Lascelles, 1997; Kaye and Dyason, 1995). The stages within the maturity model are the characteristics and behaviours displayed by an organization with respect to TQM implementation at one point in time (Dale and Lascelles, 1997). In order to understand SMEs readiness for Six Sigma implementation, the author reviewed the scant literature on the recognised TQM maturity model and understood the characteristics of firm at different stages of implementation process. This facilitated the author to construct a Six Sigma Readiness Index to assess a SME readiness to embark on Six Sigma journey.

The purpose of this section was to review commonly cited models /frameworks for quality management application in SMEs to understand the key constituents of the frameworks/models and its application in industry to date. Business Process Reengineering (BPR) literature was excluded from the review process as it focused more on breakthrough improvement rather than incremental/CI. TQM frameworks/

models proposed for large organizations were not included in the review process. Author have also omitted some articles where framework was developed based on the combined sample of small and large firm but no distinction or comparison was made between the two groups with respect to the application of framework. The author have put persistent efforts to identify and review as many frameworks/models literature on quality management application in SMEs, there may be a chance of missing/dropping few articles from the review process.

The keywords for the search used were: {(MATURITY MODELS) AND (QUALITY)}; {(QUALITY MODELS) AND (SMEs)}; {(QUALITY FRAMEWORK) AND (SMEs)}; {(TQM FRAMEWORK) AND (SMEs)}; {(LEAN FRMAEWORK) AND (SMEs)}; {(SIX SIGMA FRAMEWORK) AND (SMEs)}; {(TQM/ LEAN MODELS) AND (SMEs)}. The author first reviewed those articles that were cited most in literature as identified from reviewing extant literature on quality management applications in SMEs context. Some of the most popular study to date on frameworks/models for TQM implementation in SMEs were Ghobadian and Gallear (1997), Wilkes and Dale (1998), Husband and Mandal (1999), Watts and Dale (1999), Yusof and Aspinwall (2000 b,c) Hansson and Klefsjo (2003), Thomas and Webb (2003), and Deros *et al* (2006).

3.7.1. Assessing organizational readiness for CI journey through Maturity Model lens

This section aims to identify the characteristics/ criteria that are necessary to be present in SMEs before embarking on the journey of Six Sigma. The identification, measurement and monitoring of characteristics/ criteria may facilitate smoother implementation (without disruption) of Six Sigma across the organization. This can be achieved by briefly discussing the work of quality gurus; self-assessment models, its constituents, and applicability in SMEs environment; and finally reviewing the famous maturity models proposed for CI/TQM implementation in organizations.

Deming (1986) 14 points for management, Crosby (1979) 14 steps for implementation of TQM program, and Juran (1993) 10 steps to quality improvement were proposed based on their experience as a consultants to many large organizations. The contribution of quality Gurus to revolutionize the quality practices in large organizations cannot be understated. Most popular self-assessment models such as

Malcolm Baldrige National Quality Award [MBNQA] or European Quality Award [EQA] or Australian Quality Award [AQA] (Davies *et al*., 1996; Wiele and Brown, 1999; Wiele *et al*., 1996; Ritchie and Dale, 2000; Ghobadian and Woo, 1996) were developed based on the work of quality Gurus. The key constituents of the awards were presented in table 3.5. Most common factors appearing in all the three awards were *leadership, people management, process management, and customer focus / satisfaction*. Customer focus and satisfaction had received highest weighting in all the three awards, indicating their link to the overall philosophy of CI, i.e. customer satisfaction. Self-assessment models were used by organizations to measure their current performance against the set criteria of the model which represents a position of excellence (Kaye and Anderson, 1999). It was also used to generate awareness and interests in TQM concepts and set a platform to embark on TQM journey (Ghobadian and Woo, 1996).

The European Quality Award	The Malcolm Baldrige National Quality Award	The Australian Quality Award
Leadership (10)	Leadership (9)	Leadership (17)
People management (9)	Information and analysis (8)	Policy and planning (8)
Policy and Strategy (8)	Strategic quality planning (6)	Information and analysis (13)
Resources (9)	Human resources development (15)	People (20)
Processes (14)	Management of process quality (14)	Customer focus (22)
People Satisfaction (9)	Quality and operational results (18)	Quality of process, products and services (20)
Customer Satisfaction (20)	Customer focus and satisfaction (30)	
Impact on Society (6)		
Business Results (15)		
Note- Figures in parentheses are percentages		

Table 3.5: Factors included within three major quality awards
(Source: Ghobadian and Woo, 1996)

Nonetheless, their applications in the SMEs context is limited and have not received positive attention. The works of quality gurus or self-assessment models were less applicable in a SME environment due to critical differences in characteristics of SMEs and large organizations (Hewitt, 1997). There was a distinct lack of research and very limited evidence of success of quality systems/ self-assessment models (such as QS9000, EQA, MBNQA, etc) within SMEs context (Thomas and Webb, 2003; Wilkes and Dale, 1998; Watts and Dale, 1999; Hewitt, 1997). The quality award models had been used by companies either as an assessment tool to monitor their progress with TQM implementation or enhancing their market image by competing for quality award as a measure of TQM maturity (Yusof and Aspinwall, 2000a; Hansson and Klefsjo, 2003). It was not suited for firms beginning with the TQM journey. Once an organization has seriously embarked on the CI journey, they can use these models to assess their progress or maturity to CI implementation.

Many SMEs have the perception that these models add to unnecessary bureaucracy, excessive paperwork, time-consuming and increases complexity for the managers rather than achieving what they aim for (Watts and Dale, 1999; Wilkes and Dale 1998). Assessment models gives information on the key constituents or critical factors of the quality initiatives (addresses 'What' part or focus from systems perspective). However, SMEs need a systematic guideline or step-by-step framework (focus on 'How to' part) to facilitate successful implementation of initiatives like TQM, Lean, Six Sigma. Due to short-term focus and driven by immediate imperatives, it is challenging to generate interest in SMEs to use self-assessment with a prospect of winning an award (Hewitt, 1997). SMEs are unlikely to experience external pressure to use self-assessment model, until it comes from their larger counterpart in the supply chain (Hewitt, 1997). The self-assessment models also failed to accentuate the factors that may drive the improvement and keep the momentum between the self-assessment checks (Kaye and Anderson, 1999).

3.7.2. A review of common maturity models for CI/ TQM implementation

The first maturity model /quality management maturity grid for CI was proposed by Philip B Crosby in 1979 that mapped six categories (management understanding and attitude; quality organization status; problem handling; cost of quality as % of sales, quality improvement actions; and summation of company quality posture) behaviour across five stages (uncertainty, awakening, enlightenment, wisdom, and certainty) of their quality journey. It provided a good starting point for companies to assess their maturity in the CI journey and identify the action plan to move forward to next level. Crosby's model missed to address issues on leadership role, employee's management, and focus on key stakeholders, to name a few issues. Moreover, management and employees understanding and calculation of cost of quality were very elusive and complex.

Inspired by the work of Crosby and with the evolution of TQM, researchers proposed other CI maturity models for TQM implementation covering wider characteristics / behaviour of organizations at different stage of TQM implementation (Kaye and Dyason, 1995; Lascelles and Dale, 1991; Dale and Lascelles, 1997; Dale and Smith, 1997; Dale *et al*., 1997; Bessant and Caffyn, 1997; Bessant *et al*., 2001).

In an attempt to understand organizations positioning in the quality evolutionary process, defined in five different eras of inspection, quality control, quality assurance, strategic quality management (SQM), and beyond SQM, Kaye and Dyason (1995) examined the characteristics of 13 organizations at various stages of their quality initiatives. Firms were assessed against the critical factors identified from the interview process, listed as – leadership, strategic quality orientation, CI (internal measurement), people management, business results, and competitive CI (external measurement).

Era three: Quality assurance

Primary concern: prevention	
Leadership	Effort is co-ordinated. Responsibility for quality is defined in terms of driving and ownership
Strategic quality orientation	Performance measurement mechanisms are established. Reporting mechanisms linked to strategic management
Continuous improvement (internal measurement)	Measurement tools and techniques are used. Multi-functional problem-solving groups are established. Standards are maintained through monitoring and correction
People management	Relevant competences have been identified for staff linked to training and development strategies
Business results	Quality costs and savings measured
Competitive continuous (external measurement)	Incorporation of best practice (externally) into internal business processes

Era four: Strategic Quality Management

Primary concern: strategic impact	
Leadership	Evidence of change in culture/management style
Strategic quality orientation	Quality is integrated into business plan; linked to critical success factors. Commitment organization-wide
Continuous improvement (internal measurement)	Evidence of change to work processes. Preventive approach to errors
People management	Integrated TQM HRM resource strategies. Staff empowerment
Business results	Impact of quality measured in results. Results reviewed against objectives
Competitive continuous (external measurement)	Use of customer feedback to formulate strategy. Impact of strategy on society evaluated

Figure 3.5: Characteristics of firms in the quality evolutionary process

(Source: Kaye and Dyason, 1995)

Examining the key characteristics of each era against the CSFs (as shown in figure 3.5), it may be interpreted that positioning of the firm at era three (at least) or era four (desirable) and motivation to move ahead to fifth era or beyond SQM (exemplar case) reflects the firm's commitment to CI journey. Another popular maturity model for TQM implementation was proposed by Lascelles and Dale (1991), which was further revisited and revised by researchers based on the comments from industrial world (Dale and Lascelles, 1997; Dale and Smith, 1997; Dale *et al*., 1997). The maturity model incorporated six different levels of TQM adoption, as shown in figure 3.6, which was termed as: uncommitted (level1), drifters (level2), tools pushers (level3), improvers (level4), award winners (level5), and world-class (level6). First two levels are representatives of organization not committed to CI, lacks customer focus, operate in fire fighting mode, decisions based on gut feeling, ISO 9000 considered as destination to CI journey, blame culture, lack of vision, focus and understanding of TQM implementation across organization, bureaucratic organizational structure, to name a few. Level 2 organizations move from one-initiative to other very quickly in response to latest trend in the market. Level 3, 4, 5 and 6 have similar characteristics to Kaye and Dyason (1995) definition of era 2, 3, 4 and 5 respectively.

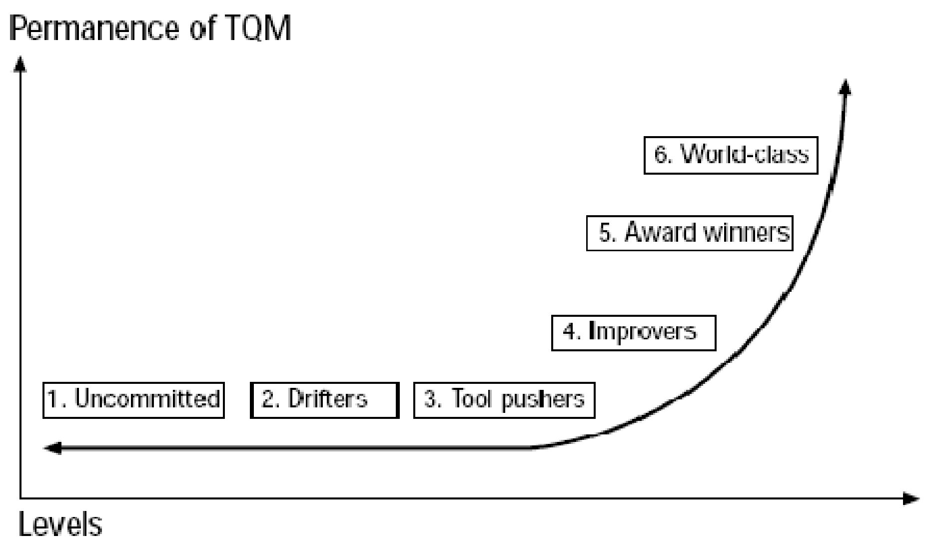

Figure 3.6: Levels of TQM adoption
(Source: Dale and Lascelles, 1991, 1997)

Dale and Smith (1997) revised the original model of Dale and Lascelles (1997) by combining drifters and tool pushers as initiators and introduced a new level termed 'unaware' before uncommitted to include those organization not acquainted to TQM philosophy. Dale *et al* (1997) further specified the key issues to sustain the TQM success- understanding of internal/external environment; management style; organizational policies and structure; and the process of change involving education and training, teamwork, QMS, use of tools & techniques, infrastructure and confidence in management.

The idea of increasing innovative capability and progression towards 'learning organization' through day-to-day practice of CI was put forward by Bessant and Caffyn (1997) and Bessant *et al* (2001). Bessant and Caffyn (1997) focused on the understanding of behavioural dimensions as organizations move through five different levels of CI capabilities. Moving from level 1 to level 5 represented the process of learning, practising, and mastering the behavioural aspects of particular characteristics of CI such as leadership or problem solving. The five different stages and their characteristics behaviour at each stage was presented in figure 3.7.

Stages in the evolution of CI	
CI Level	**Characteristics Behaviour Patterns**
Level 1 - Pre-CI Interest in the concept has been triggered - by a crisis, by attendance at a seminar, by a visit to another organisation, etc. - but implementation is on an ad hoc basis	Problems are solved randomly; No formal efforts or structure for improving the organisation; Occasional bursts of improvement punctuated by inactivity and non-participation; Solutions tend to realise short-term benefits; No strategic impact on human resources, finance or other measurable targets; Staff and management are unaware of CI as a process
Level 2 - Structured CI There is formal commitment to building a system which will develop CI across the organisation	CI or an equivalent organisation improvement initiative has been introduced; Staff use structured problem solving processes; A high proportion of staff participate in CI activities; Staff has been trained in basic CI tools; Structured idea-management system is in place; Recognition system has been introduced; CI activities have not been integrated into day-to-day operations
Level 3 - Goal Oriented CI. There is a commitment to linking CI behaviour, established at 'local' level to the wider strategic concerns of the organisation	All the above plus: Formal deployment of Strategic Goals; Monitoring and measuring of CI against these goals; CI activities are part of main business activities; Focus includes cross-boundary and even cross -enterprise problem-solving
Level 4 - Proactive CI There is an attempt to devolve autonomy and to empower individuals and groups to manage and direct their own processes	All the above plus: CI responsibilities devolved to problem solving unit; High levels of experimentation
Level 5- Full CI Capability Approximates to a model 'learning organisation'	All the above plus: Extensive and widely distributed learning behaviour Systematic finding and solving problems and capture and sharing of learning; Widespread, autonomous but controlled experimentation

Figure 3.7: Stages in the evolution of Continuous Improvement

(Source: Bessant et al., 2001)

Understanding of firm own stand on CI as compared to other company can help them to develop a plan to improve on their existing status and expand their own CI capabilities. The review of most popular CI maturity models gave information on the journey of an organization to excellence and how they can build an organizational culture based on the facets of TQM. Summarising the key findings from the review of different maturity models for CI or TQM implementation, indicates increasing maturity of an organization through gradual progression in quality management practices and behavioural dimensions linked to it. Maturity models provided a roadmap for an organization to assess their weaknesses, highlight the issues which need urgent attention, and aspire to advance to the next higher level in the CI maturity model through addressing the identified gaps in their current practices. Organizations have used the aforementioned models as guideline to embark on TQM journey or go beyond that (Dale and Lascelles, 1997; Bessant *et al*, 2001).

Understanding and follow-up of maturity models may provide a true picture of the firm's performance and assess their readiness to move to the higher level of excellence in their CI journey. Six Sigma implementation is the next stage to the total quality journey. In Section 3.2.4, critical differences between TQM and Six Sigma were discussed and reasons why organizations were embarking on Six Sigma. Understanding the characteristics of Six Sigma organizations together with the characteristics of each level of maturity models may help in assessing organizational readiness to embark on Six Sigma, i.e. the presence of key ingredients within the values and culture of organization to ensure successful implementation of Six Sigma.

Comprehending the characteristics underpinning different levels/stages of maturity models may help SMEs to evaluate their own positioning in their journey to CI and measures to implement for advancing to the next level in the maturity model. It is thus important from SMEs perspective to assess their readiness for implementation of initiatives like Six Sigma before starting actual implementation due to their limited resources and skill-sets. Any wrong implementation or false start may affect their existence in business or their commitment to the CI journey. This leads to the surfacing of the final research questions of the doctoral dissertation.

RQ5: How to assess the readiness of a SME to embark on Six Sigma journey?

Next section included review of frameworks/ models proposed for implementation of different quality initiatives, methods, or techniques within SMEs environment.

3.7.3. Background Research on quality frameworks for SMEs

Before the review process, it is imperative to understand the critical differences between framework and model and what constitute a good framework. Next section includes discussion on definition and characteristics of a framework.

3.7.3.1. What constitute a good framework?

Myriad of ‘framework’ and ‘models’ were proposed in the quality management literature without first providing an operational definition to either of it. Researchers have often used the two terminologies interchangeably in different contexts. Some define framework or model through pictorial representation of diagrams, graphs, or flowcharts, while other define it as a set of idea for one’s judgement.

Let us first have a better picture of how ‘framework’ has been defined in dictionary and by other researchers. As defined by Cambridge Advanced Learner Dictionary (2005) framework is “*a supporting structure around which something can be built; a system of rules, ideas or beliefs that is used to plan or decide something*”. Chamber’s dictionary (2003) defined framework as “*the skeleton or outline of something*”. Aalbregtse *et al* (1991) defined framework in a context of getting started with TQM implementation as being “*a clear picture of the leadership goal for the organization and should present key characteristics of the to-be style of business operations*”.

A sound framework should first assess the current state of the organization, i.e. what an organization does or trying to do, followed by analyzing the steps taken to do it in a correct sequence (Struebing and Klaus, 1997). A transparent and explicit framework should involve evaluating any new initiatives, proposals and recommendations with an appraisal in terms of validity and completeness, then assigned some measure of relative value or worth (Wilson *et al,* 1993). In the context of engineering and design, Mathaisel (2005) considered a framework as a facilitator in the unification of several disciplines in the change process to allow their combined use in the design process. There is a higher chance of success in implementing a new framework if it is supported by a good foundation, e.g. ISO 9000, including an adequately developed and well-articulated framework (Arya and Callaly, 2005).

A model, on the other hand, is defined as imitation of something on a smaller scale (Chamber's dictionary, 2003). Steinmuller (1993) defined model as "*information on something, created by someone, for somebody, for some purpose*". Comparing the definition of framework and model, it may be comprehended that model answers the query of 'what is the phenomenon of interest', whereas a framework answers 'how to' questions and provided a guideline or path to proceed forward in the implementation of 'phenomenon of interest' (Yusof and Aspinwall, 2000a).

Adopting Six Sigma as a business improvement methodology is not sufficient to emulate the success of the key players. Evidence from the literature indicates that failure to select a change management program based on structured approach or framework can lead to malpractices, fire-fighting and sub-optimization of resources (Davies and Kochhar, 2000; Goh and Ridgway, 1994). The most frequent reason cited in the literature for the failure of business improvement methodology is wrong implementation approach (Deros *et al*., 2006). This is the reason why many researchers have accentuated the development of structured framework for problem solving.

3.7.3.2. Critique of quality management frameworks and models for SMEs

There had been an implicit assumption that organisational theories, models, and conceptual frameworks developed in large organisations were relevant and directly applicable to SMEs. Literature on total quality management (TQM) / Six Sigma or assessment model such as Malcolm Baldrige National Quality Award (MBNQA) / European Quality Award (EQA) have highlighted the need for tailor made implementation framework for SMEs as the aforementioned quality initiatives or self-assessment model was developed by large organization for large organizations (Thomas and Webb, 2003; Wilkes and Dale, 1998; Watts and Dale, 1999; Wiele and Brown, 1998; Hewitt, 1997; Chittenden *et al*.,1998; Ghobadian and Gallear, 1996,1997; Yusof and Aspinwall, 2000c).

The focus of this study is to develop a customized framework for Six Sigma implementation in SMEs. The extant literature is void of such framework tailored to the needs of SMEs. This led to the review of similar framework/models on other CI initiatives such as TQM/Lean or self-assessment models/ quality management system proposed for SMEs. The purpose of this section was to review commonly cited models/frameworks for quality management application in SMEs to understand the key constituents of the frameworks/models, its application in industry, and do a critique of literature on quality frameworks/models for SMEs.

A step-by-step detailed approach to framework design can guide SMEs to successful implementation of framework, involving their own employees rather than resorting to external help. Researchers have used this prescriptive approach to develop TQM frameworks for SMEs (Asher, 1992; Ghobadian and Gallear, 1997; Hansson and Klefsjo, 2003; Ahmed *et al*., 2004). Asher (1992) four stages TQM implementation framework for SMEs namely diagnostics, commitment, implementation, and review were simple and easy for SMEs to comprehend. However, the applicability of framework within SME context was questionable as it was based on the assumption that data collection system to measure cost of quality and customer feedback system in SMEs was already developed.

Ghobadian and Gallear (1997) proposed a 10 step framework for the implementation of TQM in SMEs based on four case studies and critical review of literature. The research findings showed that the basic concept of TQM is equally applicable in SMEs, though the implementation method is different from large organization. *The inherent strength of SMEs provides them a vantage to apply TQM with considerable success* (Ghobadian and Gallear, 1996). Availability of resources was identified as a major constraint in successful implementation of TQM, though this does not preclude SMEs from TQM implementation. Management commitment, education and training, effective communication, cross-functional teamwork, and employee empowerment were identified as critical factors for TQM implementation.

The 10 step framework proposed by Ghobadian and Gallear (1997) provided a sequential step-by-step approach for TQM implementation. However, authors have missed to address the issue of resources availability to implement the framework in SMEs, staggered TQM implementation in a pilot area against full blown implementation, and rationale of implementing BS5750 in step 6 of the framework rather than before TQM implementation.

The non-acceptance of EFQM model in SME environment led Watts and Dale (1999) to develop a tailored made self-assessment model for SMEs. Self-assessment using EFQM criteria was resource intensive, weighting of criteria not applicable to small companies, difficult to understand and use for firms novice in self-assessment, and the model does not provide solution to existing problems (Wilkes and Dale, 1998). The proposed TPSBESS model seemed more flexible for SMEs as compared to original EFQM model or revised EFQM model for SMEs (Wilkes and Dale, 1998). The revised EFQM model for SMEs used simplified language, document reduced from 75 pages to 50 pages by dropping some sub-criteria from the 9 categories of the model (Wilkes and Dale, 1998). There was no changes suggested in the scoring of each criteria tailored to the needs and priority of SMEs. Based on the response of 7 case study firms, it was realised that model is still resource intensive (in terms of personnel and time), language used in the model still not clear to understand for SMEs and not user friendly from SMEs perspective.

Similar study was conducted by McAdam (2000), who questioned the efficacy and application of business excellence model (BEM) and balanced scorecard (BS) within SMEs context. The BS and BEM required diverse skill sets for effective implementation, which was not readily present in SME (McAdam, 2000; Ghobadian and Gallear, 1996, 1997). These models were based on implicit assumptions of resource availability as it was developed in large organizations (Wiele and Brown, 1998). It was also assumed that leaders and managers will be able to dedicate considerable time in implementing the models, which is not the case in SME. The leaders and managers, apart from time constraint, may not have sufficient knowledge and expertise to understand and apply the complex models (Lin, 1999). SMEs are forced to use these models, consuming their scarce resources (Ghobadian and Gallear, 1996) and add bureaucracy (Lin, 1999; McAdam, 2000) to their inherent flexible structure. Chittenden *et al* (1998) was in consensus with the aforementioned statement stating – "*these models are designed by big business for big business*".

Yusof and Aspinwall (2000c) proposed a conceptual framework, tailored to the needs of SMEs implementing TQM, consisting of three main elements of the "quality initiatives", "general methodology", and the ""central co-ordinating body", as shown in figure 3.8. Researchers conducted survey in the UK automotive SMEs followed by case studies in four firms to develop a conceptual framework. The framework included *communication, quality measurement, human resource policy, pay and reward system, employee recognition, and quality teams* within 'Quality initiatives' box, which reflects on the technical flaw of the framework as each of the aforementioned factor is an activity that contributes to TQM implementation rather than being quality initiatives themselves. Yusof and Aspinwall (2000c) failed to give an explanation on how to opertionalize the framework. As the framework was developed for automotive sector, its applicability in other manufacturing and service industry should be tested and validated.

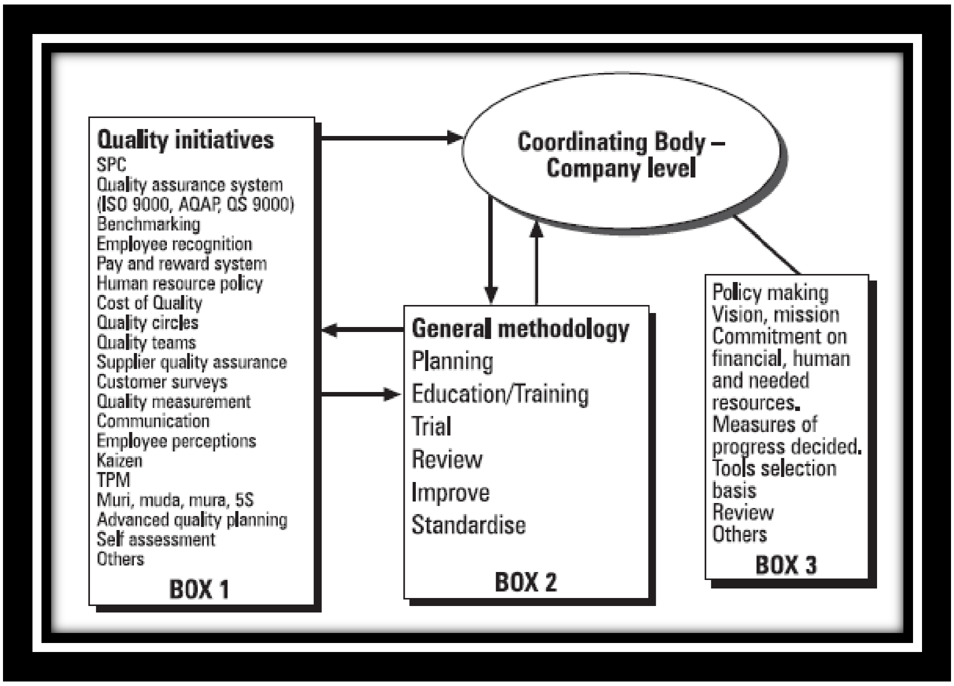

Figure 3.8: A conceptual framework for TQM implementation in SMEs
(Source: Yusof and Aspinwall, 2000c)

Husband and Mandal (1999) proposed a conceptual model to check the validity of numerous quality models or approaches suggested for SMEs in the literature. A number of dimensions (core, structural, fundamental, sustainability, integrative and external dimensions), depicted in figure 3.9, of SME were integrated to form a conceptual model. The model proposed provided a checklist for SMEs before implementing any quality methods or programmes and can also be used in a holistic manner to examine the impact of quality methods on performance of firms. The dimensional layers provided a basis for closer examination of quality methods and quality models as they apply to SMEs. The proposed model tested the validity of quality methods and drew meaningful interpretations on the applicability of model to be used by SMEs and its stakeholders.

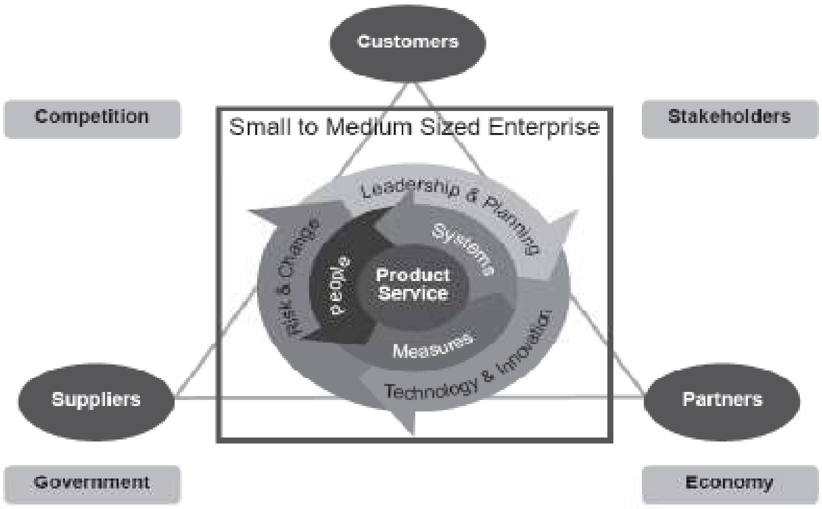

Figure 3.9: Quality Integrated management model
(Source: Husband and Mandal, 1999)

Similarly, a classification matrix was proposed by Biazzo and Bernardi (2003) for SMEs to differentiate between different self-assessment models. The quality integrated management model could be used to perform benchmarking and best practice studies (Husband and Mandal, 1999), while the classification matrix (Biazzo and Bernardi, 2003) may be used to question the meaning and substance of self-assessment model from SMEs perspective.

Taking cue from the work of Husband and Mandal (1999), Thomas and Webb (2003) proposed a SMEs specific framework consisting three stages of problem identification, problem solution, and systems development, as shown in figure 3.10. The framework was used to develop quality systems model consisting of foundation elements (SMEs factors and dimensions, training and development, project management) integrated with the working mechanisms of the model. The framework focused more on the operational issues and application of statistical methods with limited discussion on strategic issues of management commitment, resource availability to apply the framework. Limited discussion by researchers on how to make the framework operational taking into consideration the resources constraints faced by SMEs.

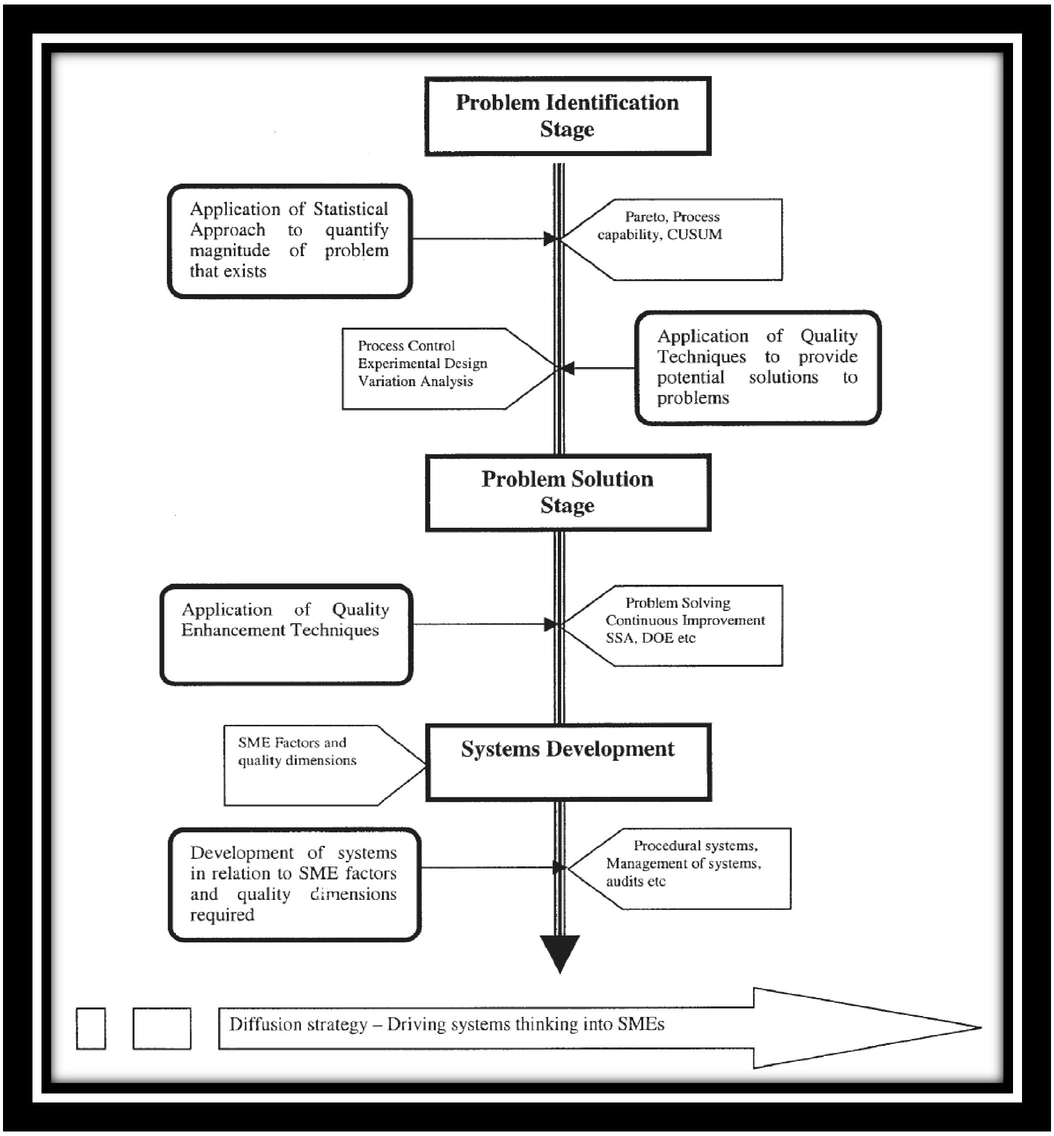

Figure 3.10: A conceptual framework for Quality model development for SMEs
(Source: Thomas and Webb, 2003)

Hansson and Klefsjo (2003), through a multiple case study of TQM in Sweden Small organizations, presented a core value model that incorporated three different partly overlapping phases starting with committed leadership, everybody's commitment, customer orientation, and followed by process focus, fact based decisions, and continuous improvements. The case study of nine organizations revealed that the aforementioned core values are permeating their organizations and they are ready to start with TQM implementation. The study also confirmed the ideas of Hellsten and Klefsjo (2000) to have suitable tools and techniques to support the core values for establishing quality culture. The empirical findings created a knowledge foundation that hopefully will facilitate the understanding of small organizations implementation of TQM.

Deros *et al* (2006) proposed a conceptual benchmarking framework based on literature review and tested the framework in six pilot automotive manufacturing companies. The framework, as shown in figure 3.11, was motivated from the work of Yusof and Aspinwall (2000c) and consists of more elements than the later. Leadership and top management commitment was considered as prerequisite to embark on benchmarking journey. The concepts within the framework were advised to be used one-at-a-time depending upon the needs and resource availability of SMEs. It is easier to start with hard performance measures to see the immediate benefits before focusing on soft performance measures.

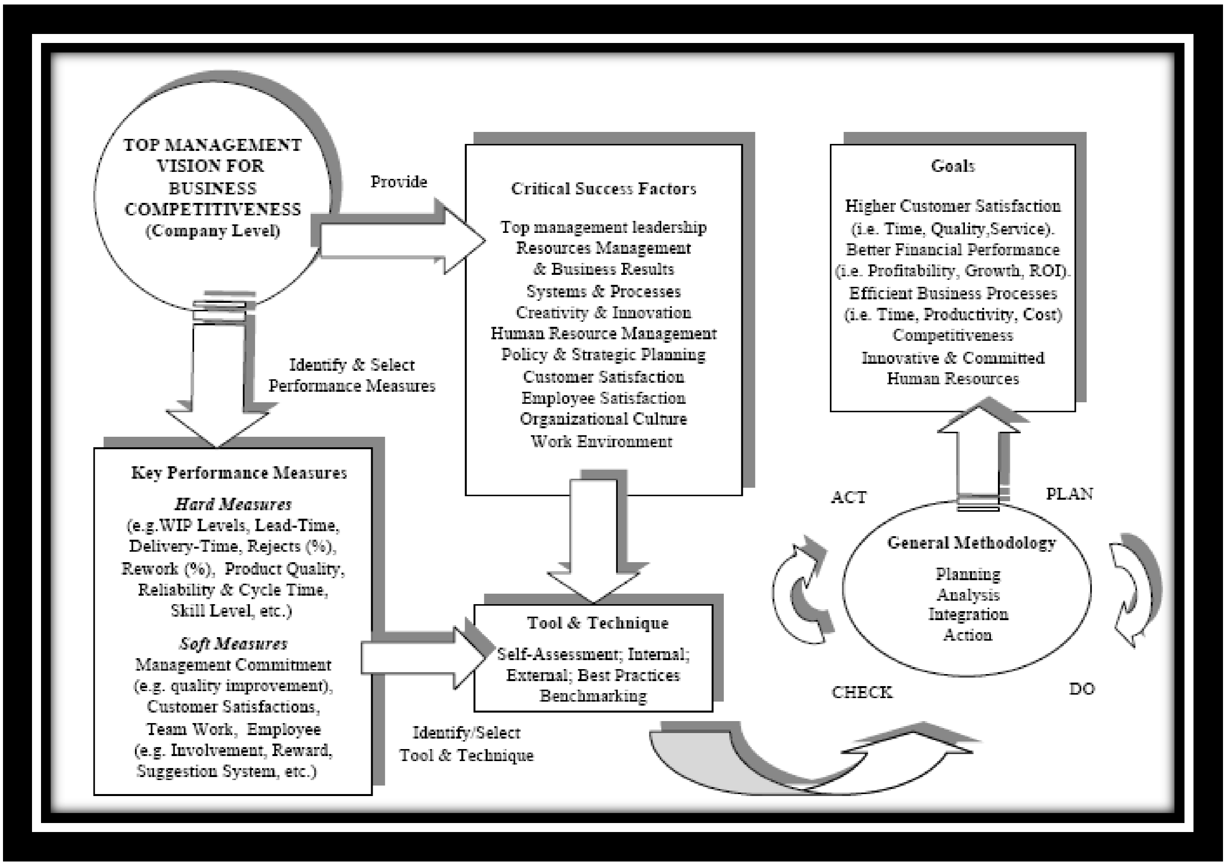

Figure 3.11: Framework for benchmarking implementation in SMEs

(Source: Deros et al., 2006)

Researchers also proposed model/framework for the effective implementation of quality techniques or methods such as JIT /5S practice/ Kanban (Gunasekaran *et al*., 2000), DoE (Thomas and Webb, 2009), and TPM (Ahmed *et al*., 2004). The aforementioned framework and models focused more on resolving shop-floor or operational problems using quality tools and techniques. Such models were not integrated at the strategic level of firms. It was identified that SMEs had limited understanding and usage of quality tools and techniques (Ahmed *et al*., 2004). Similar findings were reported in literature on the limited understanding and use of statistical tools and techniques to benchmark or identify the state of process control within SME business environment (Thomas and Webb, 2003; Deleryd *et al*., 1999; Sousa *et al*., 2005, 2006).

SMEs within construction industry have slowly started embracing the concept of TQM or quality management system to structure their systems and procedures and improve the performance of the firm (Mackau, 2003; Chileshe, 2007). Mackau (2003) integrated different management systems (ISO 9001 for quality, ISO 14001 for environment, and Safety Checklist Contractors (SCC) for occupational health and safety) to develop a new concept suitable for SMEs called integrated management system (IMS) for construction SMEs. The IMS model enhanced the motivation and eagerness of both CEO and employees during all phases of the project. Furthermore, the opinion of employees showed that the certification of the IMS worked as a motivator throughout the course of the project. Chileshe (2007) reported similar result when investigating the relationship between critical success factors and TQM implementation. It was observed that construction firm implementing TQM had CSFs ingrained within organizational culture as compared to non-TQM firms. Both the proposed model lacked instruction on how to operationalize the models. IMS seemed more complex model from SMEs perspective as it integrated three different systems that may demand more time to understand, follow and apply for certification.

Khan *et al* (2007) developed a business process improvement (BPI) framework and performance assessment methodology (PAM) tool for UK SMEs to facilitate their gradual progression to world class manufacturing (WCM) status through continuous improvement and structured training. Researchers accentuated on the role of kaizen implementation in smaller companies as it involve minimal costs and resources and can lead to improved efficiencies and profitability in short-time (Kumar and Harms, 2004; Kinni, 1995). Kaizen can be a pre-cursor to implement initiatives like TQM (Khan *et al*., 2007) in SMEs as it creates a culture of CI that allows creativity and ideas to flourish among employees, and encourages employees to take decision in a team environment (McAdam *et al*., 2000). Due to scarce resources in SMEs, Kaizen is the tailor made methodology to make incremental improvement at minimal costs in SMEs (Kinni, 1995). Influenced from EFQM model and PDCA cycle, Khan *et al* (2007) developed a BPI framework constituting six elements namely- vision, collate and measure, define and plan BPI (supported by management commitment, education, and support), management awareness, training and education on Kaizen, and check the progress, shown in figure 3.12.

To assess SMEs performance, PAM tool was proposed to identify the gap between company's current performance against WCM concepts and best practices. The framework developed is simple, easy to use for SMEs, and take into account resources constraint faced by SMEs. Initiatives like Kaizen could be used for quick wins to gain management and employees confidence before embarking on initiatives like TQM, Lean or Six Sigma.

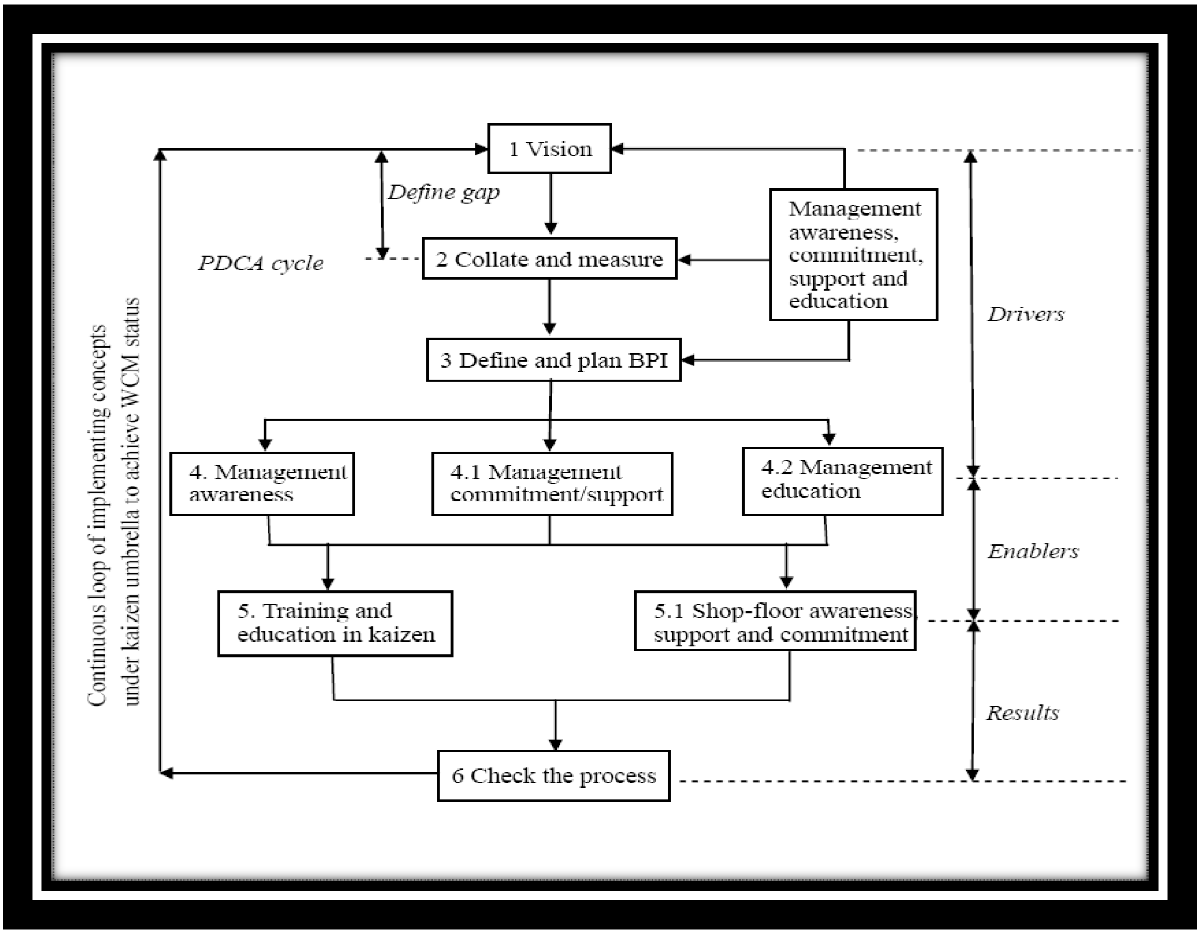

Figure 3.12: BPI framework for SMEs

(Source: Khan et al., 2007)

A table summarising the key features, methodology used in designing the framework/models, and their limitations were cited in table 3.6. It was interesting to note that majority of the frameworks/models proposed were designed based on research work in UK SMEs followed by European countries such as Germany, Sweden, and Italy. There was no framework or model (within the literature reviewed by author) proposed by taking into consideration USA SMEs, though a lot of empirical research using survey and case study had been conducted on USA SMEs.

The key findings from the review of frameworks/models were presented below

- Few frameworks proposed were developed on the assumption of data availability , customer feedback system, and strong leadership commitment, which is not the case in many SMEs
- Majority of researchers have proposed models, influenced from EFQM or PDCA cycle that gives information on the key constituents or critical factors of the quality initiatives (addresses 'What' part or focus from systems perspective). However, SMEs need a systematic guideline or step-by-step framework (focus on 'How to' part) to facilitate successful implementation of initiatives like TQM, Lean, Six Sigma. Only six out of seventeen frameworks reviewed had a step-by-step structure and rest 11 was based on systems based structure
- Very limited models/frameworks proposed on TQM/ Lean/ Six Sigma implementation in SMEs as compared to that for large organizations in quality management literature
- Most of the frameworks/models presented ignored the discussion on how SMEs with their limited resources can operationalize the frameworks/models
- Understanding of history of quality initiatives in the firm, their success rate, and leadership commitment and support in the past were not taken into consideration while designing the implementation frameworks/models for SMEs. Aforementioned issues will help to assess SMEs readiness to embark on any new initiatives like TQM, Lean or Six Sigma. Very few researchers questioned the readiness of an organization to implement initiative like Six Sigma. If the organization is not ready culturally, any change initiatives will fail drastically.

Table 3.6: Review of quality management frameworks and models for SMEs

Author (Year), Country	Methodology used	Aspects covered	Limitations/weaknesses of model/framework
Asher (1992) UK	*TQM implementation framework* developed based on consultancy experience in manufacturing and service industry	Step approach structure ; A *four stage framework*- diagnostic, commitment, implementation, and review. Establish need for change; diagnostic costs of quality, system audit, customer and employee perceptions; develop and implement quality plan; action teams; educate and train; appoint quality co-ordinator	Based on the assumption that data collection system to measure cost of quality or customer feedback system already exists.
Ghobadian and Gallear (1997) UK	*Multiple case-study* in 4 firms (Mfg.+ Service) to develop conceptual framework for TQM implementation	Step approach structure; A sequential *10 step TQM implementation framework* proposed- recognition of need for TQM; developing management and supervisors understanding; establishing goals and visions; plan implementation; educate and train all employees; create systematic procedure; align org.; implement TQM; monitor progress; continuous improvement	BS5750 may require much earlier attention then in step 6 of framework; Chances of success from full blown implementation of TQM in SMEs is meagre due to resource constraints; No validation of framework; framework constructed based on small sample-size that may limit its generalizability
Yusof and Aspinwall (2000 b, c, 2001) UK	*Survey and multiple-case study* in 4 firms to develop conceptual framework for TQM implementation; samples from UK automotive industry included in the study	System approach structure; The framework consists of *three main elements/ box*: quality initiatives, general methodology, and central co-ordinating body at company level (that focuses on vision, mission).	Does not explain how to operationalize the framework; does not provide guidance on which 'Box' to focus at the start of implementation; No validation of framework
Watts and Dale (1999) UK	Conceptual model developed based on experience; research methodology not clearly stated; indicates the use of interview and group discussion of small companies (Mfg.+ Service)	System approach structure; TPSBESS model developed as EFQM excellence model not accepted by SMEs; Key Constituent- *Customer and market focus*; *communication*; recruitment and management of personnel; financial management; *quality systems and processes*; innovation and new practice; regulations. Model avoid using weighting criteria of EFQM model	Does not explain how to opertionalize the model; though model was reported being used by SMEs, no published evidence available on the efficacy of model.
Wilkes and Dale (1998) UK	Multiple case study in 7 firms (Mfg.+ Service) to develop a revised EFQM	System approach structure; EFQM model for SMEs included original 9 categories- Leadership, People management, policy and strategy, resources, processes,	Preparation of document still resource intensive; language used still complicated from SMEs

	model for SMEs	people satisfaction, customer satisfaction, impact on society, business results; only some sub-criteria was dropped; document size reduced from 75 to 50 pages; simplified language	perspective; number of criteria does not fit a company with less than 50 employees; more samples needed for validation of model
Husband and Mandal (1999) Australia	Conceptual model developed based on literature review process	System approach structure; Conceptual model provides a checklist for SMEs before implementing any quality methods; consist of six dimensions - core, structural, fundamental, sustainability, integrative and external; model could be used to perform benchmarking and best practice studies; also to examine the impact of quality methods on performance of firms	Use of the model not evident in literature even though it provides a basis for closer examination of quality methods and quality models as they apply to SMEs
Hansson and Klefsjo (2003) Sweden	Core value model for TQM implementation developed based on multiple case studies in 9 firms (Mfg. + Service)	Step approach structure; A core value model consisting of 3 phases for TQM implementation in SMEs; Core values include- committed leadership, everybody's commitment, customer orientation, process focus, fact based decisions, and continuous improvements; tools and techniques required to support the core values	Limited discussion by researchers on how to make the framework operational taking into consideration the resources constraints faced by SMEs.
Mackau (2003) Germany	Model developed based on literature review and single case study in construction industry	System approach structure; Developed integrated different management systems(IMS) including ISO 9001, ISO 14001, and Safety Checklist Contractors (SCC); IMS enhanced the motivation and eagerness of both CEO and employees; opinion of employees shows that the certification of the IMS worked as a motivator throughout the course of the project	Model not genralizable due to small sample size (one case-study); Does not provide any information on the length/pages of document required to be filled in by SMEs for IMS certification. It is believed that a dossier containing elements of three systems (ISO 9001, ISO 14001, and SCC) would be lengthy and complicated due to integration of three systems.
Thomas and Webb (2003) UK	Conceptual framework and model developed based on survey in 500 UK manufacturing firms	System approach structure; Conceptual framework consists of three stages of problem identification, problem solution, and systems development using the integrated model proposed by Husband and Mandal (1999); Framework used to develop quality systems model consisting of foundation elements (SMEs factors and dimensions, training and development, project management) integrated with the working mechanisms of the model	Framework focuses more on the operational issues and application of statistical methods with limited discussion on strategic issues of management commitment, resource availability to apply the framework; Framework and model needs to be tested for its validity and usage in SMEs.

McAdam (2000) UK	Testing the application of Balance scorecard (BS) & business excellence model (BEM) in 20 case study SMEs by using grounded approach Industry not specified	System approach structure; BS and BEM proposed for large organizations were tested in SME environment- Both models Bureaucratic and resource consuming for SMEs; Model found to introduce a degree of mechanization and inflexibility in SMEs; Researcher sceptical about the application of models in SME context; critical factors of TQM implementation in SMEs identified- TQM strategically linked to business goals, customer satisfaction, employees participation, management commitment, processes and measures	-
Gunasekaran *et al* (2000) UK	Single case study in manufacturing SME to propose a conceptual model	System approach structure; A conceptual model for productivity and quality improvement including following elements – 5S, Hoshin exercise, activity based management, and JIT/Kanban. Model focused at operational level; variety of suggestions provided ranging from using basic tools such as Pareto to implementing JIT/Kanban, conducting time and motion study, forming self directed work team, and employee empowerment for operational improvement.	Missed to provide suggestions on how to make the model operational, strategically align to business goals, and ensure leadership commitment to introduce such model at operational level; More focus on application of tools & techniques at operational level
Khan *et al* (2007) UK	Developed a practical framework based on literature review, 150 manufacturing company survey and semi-structured interviews in 20 SMEs	Step approach structure; Developed a business process improvement (BPI) framework and performance assessment methodology (PAM) tool for UK SMEs; BPI framework constituting six elements namely- vision, collate and measure, define and plan BPI (supported by management commitment, education, and support), management awareness, training and education on Kaizen, and check the progress; PAM tool was proposed to identify the gap between company's current performance against WCM concepts and best practices; Kaizen can be a pre-cursor to implement initiatives like TQM; BPI framework a good starting point to embark on TQM, Lean or Six Sigma	Usage of PAM tool not clearly explained; Attaining world class manufacturing (WCM) status through application of Kaizen is questionable.
Deros *et al* (2006) Malaysia	Development of conceptual benchmarking implementation framework by review of literature and validating it at six automotive manufacturing SMEs	System approach structure; Framework provides a systematic approach similar to Yusof and Aspinwall (2000c) framework but with more added elements; Key constituents of framework- Top management vision, soft and hard performance measures, tools & techniques, critical success factors, general methodology (PDCA), and business goals; SMEs suggested to conduct	Framework still at development stage and needs further validation; some elements of framework connected to each other though not proven statistically;

		benchmarking on tangible measures in the start of implementation	
Chileshe (2007) UK	Development of conceptual framework by surveying 63 construction SMEs in UK	System approach structure; The systematic framework for understanding of TQM incorporate- CI constructs &concepts, practices such as process management, and tools, techniques & values such as SPC; understanding & application of TQM concepts relatively new in construction industry; critical differences observed in implementation of CSFs between TQM and non-TQM organizations	No guidelines on how to operationalize the framework; still in development stage with limited application till date
Biazzo and Bernardi (2003) Italy	Development of classification and conceptual map based on literature review	System approach structure; A classification matrix was constructed to differentiate between self assessment approaches of paradigmatic , normative, situational, normative-situational and open; map will facilitate SMEs to questions the meaning and substance of self assessment model; 5 levels of self-assessment map proposed	Application is not yet evidenced in literature; complex model; Jargon used may confuse SMEs
Ahmed *et al* (2004) Malaysia	Development of TPM/TQM implementation methodology based on completed survey response from 63 manufacturing firms	Step approach structure; 11 steps framework for TPM implementation; Key elements of framework included- understanding of needs of TPM, setting goals, team formation, training, processing data & information, long-term plan, and CI; SMEs lacked understanding and relationship between equipment maintenance and organizational performance; limited use of basic tools of quality for problem solving	Framework needs to be tested and validated for practical usage; framework was focused more at operational level and strategic issues such as leadership and management commitment, rolling out initiative on pilot basis or across organization was not included in discussion
Thomas *et al* (2008) UK	Integrated Lean Six Sigma framework based on previous model proposed by Thomas and Barton (2007). Model tested in one Mfg. SME	Step approach structure; Step by step approach to Lean Six Sigma application in SME; Focused on application of tools & techniques from the start of model implementation such as 5S, value stream mapping, DOE, ANOVA to name a few; Focus on resolving problems at operational level by applying lean tools within Six Sigma DMAIC methodology	Lacks strategic focus; Model is applicable at operational level to resolve chronic problems; It is not an implementation strategy that could be deployed across organization.

Note: In this table, no frameworks were included that was proposed only for large organizations or for both large firms & SMEs due to critical differences in characteristics of two groups; the framework/model being resource intensive & less applicable from SMEs perspective

- The important role of networking, especially with government bodies and academic institution, in supporting the CI efforts of SMEs were not addressed in majority of the frameworks/models.
- Few models focused on the application of tools & techniques of CI at operational level with little focus on integration with strategic objectives of the business. The efficacy of such models are questionable as it is softer issues such as leadership, management commitment, cultural change that impacts the success of any initiative rather than focusing on statistical methods or tools & techniques. More focus should be on softer issues at the implementation stage, thereafter hard issues such as statistics can be used for problem solving
- There was very limited discussion on how to sustain the benefits from implementation of initiatives like TQM or Lean and facilitate SMEs to become more *resilient*.

3.8. Summary

This chapter provided a brief introduction to Six Sigma, its characteristics, the DMAIC methodology, benefits from implementation, and comparison with other CI initiatives like TQM and Lean. The literature review identified the decline in TQM implementation and increasing application of Six Sigma for business process improvement in organizations. The review also indicated that Lean and Six Sigma are complementary to each other, though it is a good idea to implement Lean first before embarking on Six Sigma journey. The myths of Six Sigma were briefly presented followed by detailed discussion on one of the common myths of Six Sigma, i.e. Six Sigma can be only implemented in large organizations. The scant literature on Six Sigma in SMEs did indicated the success of Six Sigma in SMEs context, though majority of the literature was based on practical experience of researchers with little focus on theoretical underpinning. This led the author to review extant literature on CI initiatives or certification systems like ISO within the SME context.

The literature indicated difference in quality management practices in SMEs implementing TQM and non-adopter of TQM initiatives. It was also indicated from the literature that ISO may be the foundation to embark on the journey of TQM or Lean. The review of literature reported mixed results (both positive and negative result) in

SMEs due to TQM implementation. Literature was devoid of any discussion on how a SME would know their preparedness for moving to next level in their CI journey. It was also reported that majority of existing frameworks and models failed to take into account the constraints faced by SMEs while implementing QI in their respective firms. The identification of gaps in literature on CI or certification systems in SMEs led to the emergence of four research questions to be addressed in this doctoral research:

RQ2: *What are the critical differences in quality management practices of Six Sigma and non-Six Sigma SMEs?*

RQ3: *What are the critical success factors and barriers to implementation of Six Sigma in SMEs?*

RQ4: *Does the performance of Six Sigma firms differ from non-Six Sigma firms?*

RQ5: *How to assess the readiness of a SME to embark on Six Sigma journey?*

The next two chapters discussed the research paradigms and methods used to answer the aforementioned RQs.

Chapter 4
Research Paradigms

4.0. Introduction

The relationship between data and theory is an issue that has been hotly debated by philosophers for many centuries. Failure to think through philosophical issues can seriously affect the quality of management research, as they are central to the notion of research design (Easterby-Smith *et al.*, 2002). The understanding of philosophical issues can help the researchers: to clarify the research design i.e. not only looking at the evidence gathering and its interpretation, but also having the ability to answer the basic questions being investigated in the research; to choose an appropriate design for their work; and to identify and create designs that may be outside their past experience (Saunders *et al.*, 2007). This chapter gives an introduction to the research process, followed by discussion on research purpose, research paradigm, and research approach. This chapter is an important part of the thesis as it helps to decide the correct choices of research paradigm based on the rationalization of research needs.

4.1. The Research Process

Similar to manufacturing or service industry, where there is a list of activities that comprises a process, research is often thought of as a process, i.e. a set of activities unfolding over time (Ghauri and Grønhaug, 2002; Ates, 2008). The starting point of research, as shown in figure 4.1, is to select the topic / phenomenon to be studied that may be of researcher’s own interest or of the public/ organization’s interest or affecting the government rules and regulations. A research topic is different from a research problem – the former is broader and more general whereas a research problem is more specific to the research context. The research purpose and questions were discussed in Chapter 1. A brief introduction to research questions is included in the next section to link it to the research paradigm, discussed in this chapter and to research design discussed in Chapter 5.

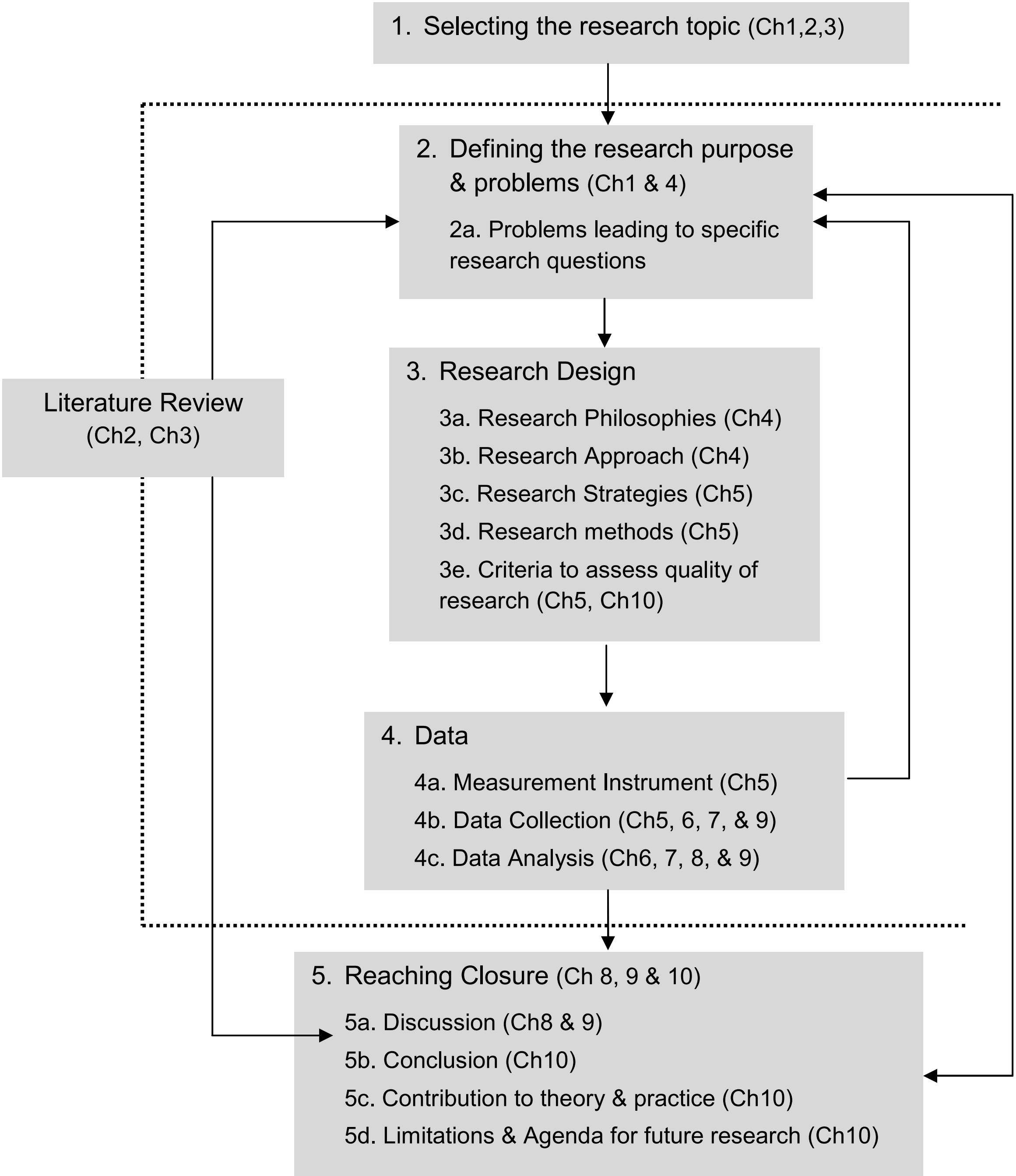

Figure 4.1: The research process

[Adapted from Ghauri and Grønhaug (2002) & Ates (2008)]

The research questions were framed based on review of literature (discussed in Chapter 2, and Chapter 3) on SMEs growth, quality management practices and framework/models proposed for quality improvement in SMEs. A clear research question is a point of departure for further research activities (Ghauri and Grønhaug, 2002). It was clearly demonstrated from figure 4.1 that the research process in management studies was not much different from practical problem solving. It was based on a series of activities, as shown in figure 4.1 that facilitate the construction of new theory or test existing theory.

4.2. Research purpose and questions

Rowlands (2005) emphasized that the starting point in any research project is to understand the nature of the research problem that leads to the choice of an appropriate methodology. The researcher should be clear in his/her intent to conduct the research, i.e. its purpose. The statement of purpose conveys to the researcher what the result of the research was likely to accomplish (Marshall and Rossman, 1999:33). A clear and succinct statement may help to frame the research questions for the project. Similar to the way that an architect needs to know the purpose of a building before designing it (is it a bungalow, flat, office building, a factory?), the researcher must be clear about their research purpose and research questions before developing a research design (de Vaus, 2005:17). The relationship between the research purpose and research questions was presented in table 4.1.

The purpose of the research may be to describe (discover), explain (develop), explore (understand), or take action as part of the intention of the proposed study. As discussed in Yin (2003), *descriptive* research focuses on 'what, who, and where' questions; *explanatory* focuses on 'how and why' questions; and *exploratory* focuses on 'what' questions. Descriptive research is undertaken for the purpose of producing accurate representation of persons, events, or situations (Saunders *et al*., 2007). It emphasizes on reporting and recording elements of situations and events (Meredith *et al*., 1989). The explanatory research focuses on studying a situation in order to explain the causal relationship among variables existing within the object of study. Exploratory research aims to seek a new insight into phenomena, ask for more detailed levels of description with respect to the object of study, ask questions and assesses the phenomena in a new light. The results from the preliminary descriptive research may be used to conduct detailed study of the object, leading to further insight and understanding (Meredith *et al*., 1989). Depending upon the type of research the researcher intends to conduct, he/she can define the questions as per the general guidelines provided in the table 4.1.

Table 4.1: Matching research questions and purpose

Purpose of the study	***General Research Questions***
Descriptive:	
To document and describe the phenomenon of interest	What are the salient actions, events, beliefs, attitudes, and social structures and processes occurring in this phenomenon?
Exploratory:	
To investigate little-understood phenomena	What is happening in this social program?
To identify or discover important categories of meaning	What are the salient themes, patterns, or categories of meaning for participants?
To generate hypotheses for further research	How are these patterns linked with one another?
Explanatory:	
To explain the patterns related to the phenomenon in question	What events, beliefs, attitudes, or policies shape this phenomenon?
To identify plausible relationships shaping the phenomenon	How do these forces interact to result in the phenomenon?

(Adapted from: Marshall and Rossman, 1999:33)

The purpose of this study was to assess the status of Six Sigma implementation in UK manufacturing SMEs. Six Sigma is gaining momentum as one of the most effective business process improvement strategies among a large number of multinational organizations. To date, the benefits of Six Sigma have primarily been realised by large organizations and the question therefore remains how best to apply Six Sigma in a SME context.

This research was carried out in *three stages*. In stage 1, *an exploratory research* was undertaken to identify the quality management practices existing in UK manufacturing SMEs. The database generated from the first phase of study was used to conduct an *exploratory study* in the phase two of the research to get a better insight into the quality management practices in selected few SMEs. The output from the first two phases was used to construct a Six Sigma Readiness Index and a framework for SMEs that was further tested in the third phase of the study. Thus a triangulation approach was used to explore the practicality of Six Sigma implementation within UK SMEs and answers the following research questions:

RQ1: *What makes SMEs different from large organizations?*

RQ2: *What are the critical differences in quality management practices of Six Sigma and non-Six Sigma SMEs?*

RQ3: *What are the critical success factors and barriers to implementation of Six Sigma in SMEs?*

RQ4: *Does the performance of Six Sigma firms differ from non-Six Sigma firms?*

RQ5: *How to assess the readiness of a SME to embark on Six Sigma journey?*

These questions were derived from the literature review discussed in Chapter 2, and Chapter 3. The answers to these questions were mapped with the findings from the literature review to construct a practical and user friendly framework for Six Sigma implementation in SMEs. The next section discusses the different research philosophies and approaches applicable to management studies.

4.3. Research Paradigms

A paradigm is a basic set of beliefs about the world (Denzin and Lincoln, 2000); a set of methods that all exhibit the same pattern or element in common (Meredith *et al*., 1989); progress of scientific practice based on people's philosophies and assumptions about the world and the nature of knowledge (Collis and Hussey, 2003); a set of linked assumptions, rules, and perceptions about the world which is shared by a community of scientists investigating the world (Deshpande, 1983: 101; Gummesson, 2000). Researchers have used the term *paradigm* quite loosely and interchangeably in academic research, that may have a different meaning to different people. Burrell and Morgan (1979) in Collis and Hussey (2003), suggests three different interpretations of paradigm at three different levels:

- at the *philosophical level*, it is used to reflect a basic set of beliefs about the world

- at the *social level*, it is used to provide guidelines to a researcher in pursuing his / her research

- at the *technical level*, it is used to specify the choice of methods and techniques appropriate to answer the research questions or when conducting research

The understanding and impact of these paradigm or philosophical issues on the quality of management research is considered highly relevant (Amaratunga *et* al., 2001; Easterby-Smith *et al*, 2002; Collis and Hussey, 2003; Mendibil, 2003; Lopez, 2005). Understanding of philosophical issues is useful to clarify the research design (what, why, how questions; its interpretations; and data analysis); recognize the suitability of designs & their choices based on research questions; use and apply a design that may be outside the researcher's past experience (Easterby-Smith *et al*, 2002).

There are a number of classifications of paradigm at the philosophical level existing in the literature. Meredith *et al* (1989) highlights the dimension that shapes the philosophical basis for research activity- *rational/existential dimension*. This dimension is concerned with the nature of reality and whether there is just one reality, which is logical and independent of the researcher, or the reality is subjective and socially constructed. For the same dimension, researchers have used alternative terms labelled as *positivist* and *phenomenological* (Easterby-Smith *et al*., 2002; Saunders *et al*., 2007; Collis and Hussey, 2003; Clough and Nutbrown, 2002; Gummesson, 2000; Gill and Johnson, 2002). Some authors have proposed intermediate dimensions between positivist and phenomenological sides such as Axiomatic (Meredith *et al*., 1989); Critical theory (Meredith *et al*., 1989; Healy *et al*., 2000); Relativist (Easterby-Smith *et al*., 2002); Realist (Healy *et al*., 2000); Social Constructivist (Easterby-Smith *et al*., 2002; Healy *et al*., 2000; Lincoln and Guba, 2000); Interpretivist (Meredith *et al*., 1989) and Post Positivist (Lincoln and Guba, 2000) to name a few. Researchers in the past have used the term social constructivist and Interpretivist interchangeably within phenomenological dimensions of the research philosophy.

For the purpose of this research, the author focuses on two main research paradigms- Positivist and Phenomenological, and these terms will be used hereafter in the sections and chapters to follow. These two paradigms may be considered as the two extremes of a continuum. As one move along the continuum, the characteristics and assumptions of one dimension are gradually relaxed and replaced by those of the other paradigms (Collis and Hussey, 2003).

4.3.1. Basic assumptions of the main paradigms

Before discussing the two paradigms in detail, the author would like to introduce the assumptions of paradigms in order to better understand the differences among them- ontological; epistemological; axiological; and methodological (Easterby-Smith *et* al., 2002; Healy *et al*., 2000; Collis and Hussey, 2003, Creswell, 1994; Lincoln and Guba, 2000:165). Easterby-Smith *et* al (2002:31) defines *ontology* as the assumptions we make about the nature of reality. The key ontological question is '*what is the form and nature of reality and, therefore, what is there that can be known about it?*' (Mason, 2002). As stated by Collis and Hussey (2003:48), with the ontological assumptions, the researcher must decide whether he / she considers the world as objective and external to the researcher (Objective Ontology) or socially constructed and only understood by examining the human actor's interpretations and perceptions (Subjective Ontology).

Epistemology involves inquiring into the nature of the world in the best possible way (Easterby-Smith *et* al., 2002). It is concerned with what constitutes acceptable knowledge in a field of study (Saunders *et al*., 2007) and involves an examination of the relationship between the researcher and what is being researched (Collis and Hussey, 2003). The key epistemological questions are 'What is the relationship of the researcher to that researched and what can be known?' Should the researcher remain independent of that being researched in an attempt to control bias (positivist), or should the researcher interact with those being studied (phenomenological)? Different epistemologies have different things to say about the aforementioned questions and about what the status of knowledge can be (Mason, 2002). *Ontological and epistemological issues become related in the sense that the latter concerns how human actors may go inquiring about and making sense of the former.*

Axiology is a branch of philosophy that studies judgements about 'value' (Saunders *et al*., 2007). Values reflect either the personal beliefs or feelings of a researcher (Bryman and Bell, 2007:29). Axiology is concerned with the process of social enquiry and is greatly influenced by the role played by human actors/ researchers in all stages of the research process to provide credibility to the research findings. It is expected of the social scientists to be value free and objective in their research, i.e. avoiding intrusion and biasness in the course of research. These assumptions are commonly found in the research studies in natural sciences, but they are less convincing in social sciences which are concerned with the activities and behaviour of people (Collis and Hussey, 2003: 48). The key research question underpinning axiological assumptions is *'What is the role of values?'*

Lastly, the *methodological assumption* is concerned with the process of the research (Collis and Hussey, 2003). It involves combination of approaches used to enquire into a specific situation (Easterby-Smith *et* al., 2002; Lincoln and Guba, 2000). It refers to the overall approach to the research process, i.e. is the process of research deductive (testing of hypothesis or propositions derived from the theory to better predict, explain, and understand the phenomena of interest) or inductive (theory is generated based on empirical research)? The key methodological question is '*How can the researcher go about finding out whatever he or she believes can be known?'*

4.3.2. Debates confronting Positivist and Phenomenological paradigms

Approaches to research in social science evolved significantly over the course of the twentieth century. Management research evolved from a broadly positivist approach to the discrimination of reality (Smallbone and Quinton, 2004). Historically, the positivistic paradigm in the social sciences was based on the approach used in the natural sciences, such as biology, botany, and physics (Collis and Hussey, 2003; Smallbone and Quinton, 2004).

According to the *positivist paradigm*, the social world is independent and exists externally regardless of whether the researcher is aware of it and its properties are measured through objective methods (Easterby-Smith *et al*., 2002; Meredith *et al*., 1989; Collis and Hussey, 2003). Here, the researcher's personality, political views and religious beliefs do not interfere with the research results. The understanding that researchers should always be objective in his or her work comes from this positivistic paradigm. Thus, logical reasoning is applied to investigate the research problem under this paradigm, with a focus on precision, objectivity, and rigour to replace hunches, experience, and intuition.

During the last three decades, social scientists have severely criticised the positivistic perspective and argued that social sciences deal with action and behaviour which are generated from within the human mind (Collis and Hussey, 2003; Eisenhardt, 1989; Yin, 2003). This school of thought believes that the investigator and the object of study are interactively linked so that findings are mutually created within the context of the situation which shapes the inquiry (Lincoln and Guba, 2000; Denzin and Lincoln, 2000). Popper (1994) supporting the argument state that creation of immutable laws will lead to the stagnation of theory and that theory development should be open to criticism. The proponents of such philosophical thoughts fall under the *phenomenological paradigm*. This is concerned with the understanding of human behaviour from the researcher's own frame of reference (Collis and Hussey, 2003). Thus, this paradigm argues that there is not just one reality, but as many as individual interpretations there might be (Lopez, 2005).

The basic ontological, epistemological, axiological, and methodological assumptions underlying the two paradigms were presented in table 4.2.

Table 4.2: Assumptions of the two main paradigms

Assumptions	***Question***	***Positivist***	***Phenomenological***
Ontological	What is the nature of reality (truth)?	Reality is external and objective. Reality is singular, apart from the researcher	Reality is socially constructed and subjective. Reality is multiple as seen by observers in a study
Epistemological	What is the relationship of the observer to that observed?	Observer is independent from that being researched	Observer is part of what is observed
Axiological	What is the role of values?	Value-free and unbiased	Value-laden and biased
Methodological	What is the process of research?	Deductive process Static design Context- free Generalizations leading to prediction, explanation and understanding	Inductive process Emerging design Context-bound Patterns, theories developed for understanding

(Adapted from Lincoln and Guba, 2000; Easterby-Smith et al., 2002; Creswell, 1994, Mendibil, 2003, Lopez, 2005)

Positivist concerns to uncover truths and facts using experimental or survey methods have been challenged by phenomenologist who assert that these methods impose a view of the world on the subject rather than capturing, describing and understanding these world views. The research problem undertaken by a phenomenologist does not involve examining facts to discover their underlying structure, but understanding a phenomenon from the viewpoint of the individual involved in its creation in accordance with their own language, representation, motives and intentions (Hirschman, 1986). The researcher will be able to develop an inside understanding of the social realities by immersing himself or herself in the context.

The assessment of phenomenological research differs from positivist theory assessment. Positivists seek rigor using statistical criteria and conceptions of reliability and validity to evaluate the quality of quantitative findings. Sample size, common methods bias and sampling error are common concerns. In contrast, meaning focused research in the phenomenological tradition is assessed in terms of *trustworthiness criteria* including credibility, transferability, dependability and conformability and *authenticity criteria* including fairness and ontological, catalytic and tactical authenticity (Lincoln and Guba, 2000). Other differences between the two paradigms are presented in table 4.3.

Table 4.3: Paradigm position on selected issues in social science research

Issue	***Positivist***	***Phenomenology***
Aim	Discovery	Invention
Research goal	Discover and explain the structure of reality	Understand the significations people attach to social reality, and their motivations and intentions
Subject-object relationship	Independent	Interaction
Origin of Knowledge	Observation of Reality	Empathy
Validity of Knowledge	Consistency with facts	Consistency with experience
Nature of Research Problem	Examination of the facts	Development of an inside understanding of a phenomenon
Origin of the research problem	Identification of theoretical inadequacies for explaining or predicting reality	Immersion in the phenomenon studied
Research position	Prescriptive, causal, deductive	Descriptive, Inductive

Starting points	Formulation of explicit hypothesis	Meaning/ research questions
Techniques	Measurement	Conversation
Sample size	Large	Very Small
Analysis / Interpretation	Verification /falsification	Sense-making
Type of data analysis	Statistical methods	Non-statistical
Causality	Cause-effect relations	Not addressed
Outcomes	Causality	Understanding
Judgement of research quality	External validity and reliability are critical	Credibility, transferability, dependability, and confirmability

(Adapted from Easterby-Smith et al., 2002; Lincoln and Guba, 2000; Ates, 2008)

4.3.3. Inductive and Deductive Research Approach

The researchers are working with the production of theories that are going to give knowledge of reality. To accomplish this, the researcher has to relate theory and reality to each other. How to relate theory and reality is one of the most central problems in all research work. There are two alternative ways of working to which the production / testing of theory can be carried out: deductive approach and inductive approach (Ghauri & Grønhaug, 2002; Saunders *et al*., 2007; Easterby-Smith *et al*., 2002; Denzin and Lincoln., 2000), as shown in the figure 4.2.

In the inductive approach, based on empirical evidence we come to a conclusion or propose a theory. However such conclusions should be treated cautiously as they are based on some empirical observations. On the other hand, the deductive approach uses an existing theory to test a hypothesis under different contexts / scenario. In this case, we draw conclusions based on logical reasoning, i.e. we gather facts to confirm or disprove a hypothesis (of relationship among variables) that was deduced from propositions (Ghauri & Grønhaug, 2002).

The deductive approach is distinguished by researcher drawing conclusions from general principles and existing theories. From existing theory, a hypothesis is derived and thus it is empirically proven in the actual situation. An available theory decides what information should be gathered, how to interpret this information and how to relate the results to the already existing theory.

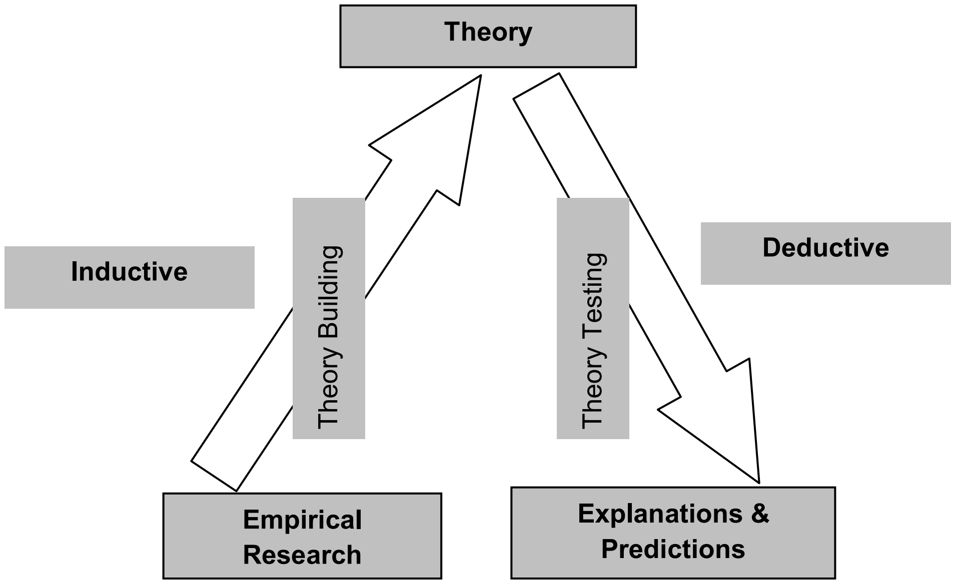

Figure 4.2: Comparison of inductive and deductive research approach
(Adapted from Chalmers, 1982:6)

The inductive approach is the counterpart to the deductive approach. The researchers are studying the object of research and from the information gathered, they are formulating a theory. There is a risk that the researcher does not know anything about the range and generality of theory, since it is based on empirical research, typical for a special situation, time and people.

The purpose of any research is either to build a theory or to test an existing theory. In theory construction, the research process begins with observations / data collection, as shown in figure 4.3, and uses inductive / qualitative reasoning to derive a theory from these observations. The focus here is to question whether the observation is a particular case of a more general factor or the observation fits into a pattern or a story (de Vaus, 2005:6). On the contrary, theory is a starting point in the theory testing approach to guide which observations to make- from the general to the particular (de Vaus, 2005:6). Deductive reasoning is used to derive a set of hypotheses, which are tested against data collected through a particular method to prove or disprove the hypotheses, thus accepting or rejecting / modifying the existing theory.

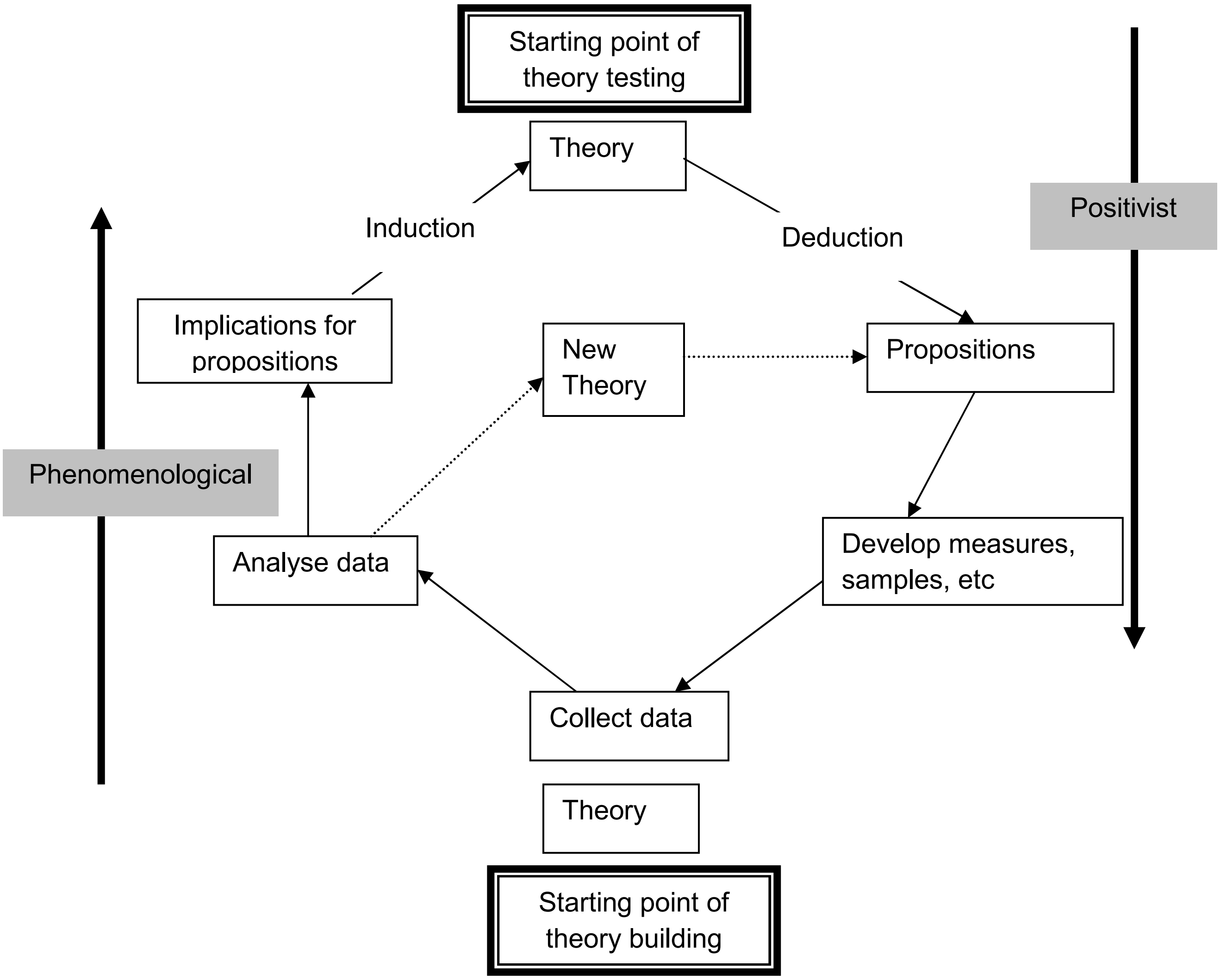

Figure 4.3: The logic of the research process
(Adapted from de Vaus, 2005:8)

From figure 4.3, it can be stated that the deductive approach is best suited for research falling within the positivist paradigm, whereas inductive approach can be used to socially construct the reality under the phenomenological paradigm. However, it is not prudent to comment on which paradigm is better, a trap that researchers may fall into thinking one research approach is 'better than other'. Each philosophy or approach is 'better' for doing different things. The question that should be asked in choosing between different paradigms or approaches is which philosophy or approach can provide answers to the research question(s) posed by the researcher.

Combining inductive and deductive approaches in a single study is widely practiced and accepted in many areas of social science research (Easterby-Smith *et al*., 2002; Yin, 2003; Saunders *et al*., 2007). The evolving pluralism of research methods being used to study the problems in organizations makes multi-method research a seemingly valuable approach. There are at least two reasons that underlie the potential value of multiple methods. The first reason is that using multiple methods mitigate the limitations existing in any one of the research methods. The second reason is that multi-method research is more than using two disparate methods (generally a quantitative and a qualitative method) in the course of your research effort. The use of different research approaches, methods and techniques in the same study is known as triangulation and can overcome the potential bias and sterility of a single method approach (Collis and Hussey, 2003). Denzin and Lincoln (2000) supporting the triangulation approach states that the use of multi-methods to study the same phenomena by a number of researchers, if the conclusions are the same, will lead to greater validity and reliability than a single methodological approach.

4.4. Implications of Research Philosophy and Approach on this study

The practical reality is that research rarely falls neatly into only one philosophical domain as discussed in the above sections. The research issue- “Six Sigma implementation in UK manufacturing SMEs”, established in Chapter 1 and the research purpose discussed in the section 4.2, clearly indicates that this research does not fall on either side of the philosophical continuum. From the ontological perspective, the exploratory research undertaken in the three phases (using survey and case study methods) clearly follows *objective ontology*. In the second phase of research, while undertaking the case studies, the researcher was an independent observer and was seeking explanations for the quality management practices in case study companies. The researcher was in no way trying to influence the result of the study and remained as an independent observer throughout the research process.

From the epistemological perspective, the author adopted a *triangulation of both phenomenological and positivist paradigm,* where both hard and soft data was collected to realise the research aim. In the *first phase of study, where a survey was conducted, the epistemological stance is positivist*. While in the *second and third phase of the study, the adopted case study method falls under the umbrella of phenomenological paradigm*. The author in the positivist paradigm assumed the role of an objective analyst, making detached interpretations and conducting tests about data collected in an apparently value-free (axiology) manner (Saunders *et al.*, 2007). From the phenomenological perspective, knowledge and reality are socially created and given meaning by people (Easterby-Smith *et al*, 2002). The author acted as a phenomenologist in phase two and three to view the process of understanding as it contributed to the construction of the reality. In the last two phases of the research, the author takes into account the more sensitive aspects of research and includes value-laden (axiology), rich data (interviews, etc.).

A triangulation approach of inductive and deductive research was undertaken from the methodological perspective. In the first phase of the study, a survey instrument was designed based on the existing literature/theory on quality initiatives in SMEs. The purpose of this phase was to identify SMEs implementing different quality initiatives and compare their quality management practices. This phase was needed to understand the current status of Six Sigma implementation in SMEs. The second phase was very informal and the author visited case study companies with an open mind to understand the impact of quality initiatives on the performance of the company. Thus, this phase falls under the category of inductive research.

4.5. Summary

This chapter discusses research from a process perspective by breaking down the entire doctoral research into a list of activities that are undertaken in the ten chapters of the dissertation. Understanding the purpose of the research and the nature of research questions facilitated in identifying the nature of the research (descriptive, explanatory, exploratory), the philosophical stance (positivist vs. phenomenology) of the researcher, and the methodology (inductive vs. deductive) used for the research. The next chapter discusses the research strategies and data collection methods used, the unit of analysis, and the quality criteria for the research undertaken. At each level of the paradigm discussed, the author adopted a triangulation approach to answer the research questions. The exploratory study was carried out under the umbrella of positivist and phenomenological paradigms to access the vast detail of phenomena under study.

Chapter 5

Research Design

5.0. Introduction

The objective of this chapter was to explicate the term 'research design', its relationship with different philosophical paradigms and approaches, followed by the choice of research strategies and data collection methods adopted for this research. The understanding of research design is imperative as it provides a well thought-out logical and rational plan to address the research questions. The selection of appropriate research strategy and data collection methodology for this study was influenced by the selection of appropriate research questions and philosophical paradigms from the previous chapter. The chapter also includes discussion on the research quality criteria used to evaluate the overall quality of the research and measures taken by the researcher to ensure the fulfilment of the criteria.

5.1. What is Research Design?

The role of research design in identifying the issues and planning the research is imperative. Researchers have proposed several definitions of research design, none of which seems complete or imparts the full range of important aspects.

"Research Design constitutes the blueprint for the collection, measurement, and analysis of data" - Cooper and Schindler, 2006: 138.

"It is the overall plan for relating the conceptual problem to relevant and practicable empirical research" - Ghauri & Grønhaug, 2002:47

"A Research Design provides a framework for the collection and analysis of data" - Bryman and Bell, 2007:40

"Research Design is a logical sequence that connects the empirical data to study's initial research questions and, ultimately, to its conclusion" - Yin, 2003:20

"*Research design is a blueprint of research dealing with at least four problems: what questions to study; what data are relevant; what data to collect; and how to analyze the results"* - Philliber *et al*., 1980 cited in Yin, 2003

Among the five definitions cited above, Philliber *et al* (1980) had managed to cover the important constituents of a research design, i.e. connecting the research questions to data collection, measurement, and analysis phase. Understanding the role and purpose of research design is vital in knowing where the design fits into the entire research process from framing research questions to finally analysing and reporting data (de Vaus, 2005:9). Many text books on research design have *used the term 'research design' and 'research method' interchangeably, though there is significant difference between the two*. Research design entails a logical structure of research enquiry, whereas research method is treated as a mode of data collection. Research method is one of the subsets of research design as shown in figure 5.1.

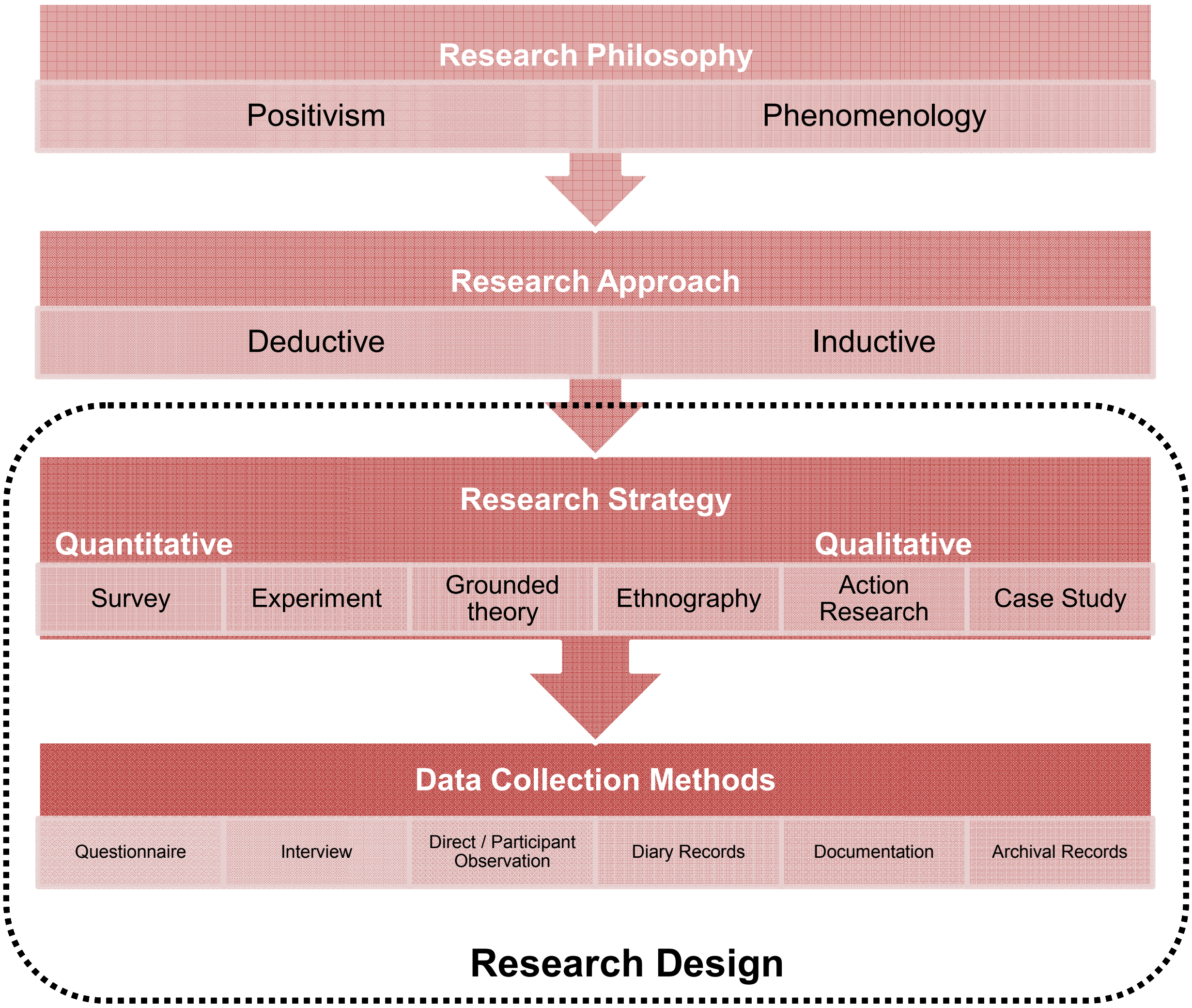

Figure 5.1: The position of research design with research process flowchart
(Modified from Saunders et al, 2007)

The dotted line encircling the research strategy and data collection methods in figure 5.1 constitute the research design. A choice of research design reflects decisions about the priority being given to a range of dimensions of the research process (Bryman and Bell, 2007:40). The forthcoming sections include the following elements of research design- research strategies (Qualitative vs. Quantitative), research methods (data collection techniques), and research quality criteria.

5.2. Research Strategies

Research strategy refers to a general orientation to the conduct of business research (Bryman and Bell, 2007:28). Research strategy is a systematic and orderly approach taken towards the collection and analysis of data so that information can be obtained to answer the research questions posed by the researcher (Jankowicz, 2005). Research strategy is classified at two levels- level 1 takes into consideration the quantitative and qualitative research (Bryman and Bell, 2007); and level 2 forms the distinctive cluster of strategies such as experiments, survey, case study, ethnography, grounded theory, and action research (Saunders *et al*., 2007). The author first introduced the differences between qualitative and quantitative research and the importance of triangulation in carrying out effective research. This was followed by further discussion on different available strategies in business research.

5.2.1. Quantitative and Qualitative Research

The assumption underlying the quantitative research is that research designs should be based on an objective view of the world and follows the positivist paradigm (Easterby-Smith *et al*., 2002). The goal is to measure and analyze causal relationships between variables within a value-free framework (Denzin and Lincoln, 2000). Techniques to ensure this include randomization, blinding, highly structured protocols, and written or orally administered questionnaires with a limited range of predetermined responses. Sample sizes are much larger than those used in qualitative research so that statistical methods to ensure that samples are representative can be used (Carey, 1993). Other details of quantitative research were provided in table 5.1.

Table 5:1: Critical differences between qualitative and quantitative research strategies

Qualitative	Process of Research	Quantitative
Understand & interpret	***Focus of research***	Describe, explain, and predict
Inductive; generation of theory	***Principal theoretical orientation***	Deductive; testing of theory
Phenomenological	***Epistemological orientation***	Positivism
Subjectivity (Constructivism)	***Ontological orientation***	Objectivism
Minor role; justify problem	***Literature used***	Major role to justify problem; identify questions and hypothesis
Understanding the inter-relationship of different variables	***Purpose of inquiry***	Explanation and control
High- researchers is participant & catalyst	***Researcher Involvement***	Limited; controlled to prevent bias
Non-probability; purposive	***Sample Design***	Probability
Small	***Sample Size***	Large
Verbal or pictorial description; non-numerical data	***Data Type***	Mainly numerical data
Descriptive analysis by interpretation of data	***Data Analysis***	Statistical techniques
Rely on the participants, the researcher , or the reader	***Data Validation***	Rely on external standards such as judges, past research, statistics
Knowledge constructed	***Output***	Knowledge discovered
Analytical	***Generalization***	Statistical
Patterns of unanticipated as well as expected relationship	***Research question seeks***	A relationship between a small number of variables

(Adopted and modified from Creswell and Clark, 2007:29; Cooper and Schindler, 2006:199; Bryman and Bell, 2007:28; Stake, 1995:37; Martinez-Hernandez, 2003:64)

In contrast, the qualitative research is based on phenomenological paradigm (Easterby-Smith *et al*., 2002). The emphasis of qualitative research is on process and meanings. Techniques used in qualitative studies include in-depth interviews, focus group interviews and participant observations. Samples are not meant to represent large populations. Rather, small, purposeful samples of articulate respondents are used because they can provide important information, not because they are representative of a larger group (Reid, 1996). The other differences between the two strategies were presented in table 5.1.

5.2.1.1. Mixed-Method Research

The distinction between qualitative and quantitative research is subtle, with researchers suggesting the use of different strategies and methods whenever possible, and also occasionally move across paradigms with care (Easterby-Smith *et al*., 2002; de Vaus, 2005; Martinez-Hernandez, 2003). It is not compulsory that a specific design should use a particular method of data collection- data for any design can be collected using any data collection method (de Vaus, 2005:9). For example, if a type of design used for research is the case study, the data collection methods may be questionnaire, interview, observation, analysis of documents, etc. However, there were arguments against using mixed-method research due to two reasons- the idea that the research method carries epistemological commitments; and the idea that qualitative and quantitative research are two different paradigms (Easterby-Smith *et al*., 2002; Smith, 1983).

The reality is that careful use of mixed-method research can help in combining the advantages of both qualitative and quantitative methods within a single project (Bryman and Bell, 2007, Creswell and Clark, 2007; Teddlie and Tashakkori, 2009). The evolving pluralism of research methods being used to study the problems in organizations makes mixed-method research a seemingly valuable approach. The combined approach may also enhance the generalizability of the research findings (Teddlie and Tashakkori, 2009; Creswell and Clark, 2007). Each research strategy has limitations in addressing all aspects of validity (construct, content, and external validity) and so triangulation using the mixed-method approach may help to maximize the research validity (Scandura and Williams, 2000).

Analogous to blind men examining and defining the elephant in their own way, Boyer and Swink (2008) comment on that the researcher own proximity for the methodology they are most familiar and comfortable with governs the selection of strategy for answering the research questions. It is imperative to set aside individual biases towards a strategy or method for the advancement of research in operations management. Boyer and Swink (2008) further explicate the point by the following quote- *"After all, blind men use all their senses to compensate for the lack of vision. Why should we as researchers disparage any avenue of inquiry that will help describe the elephant?"*

Hammersley (1996) in Bryman and Bell (2007) proposed three approaches to mixed-methods research

1. Triangulation- where the qualitative research is used to support quantitative research findings or vice versa
2. Facilitation – refers to the use of one research strategy to aid research using the other research strategy
3. Complementarity - refers to the use of two different research strategies to dovetail the different aspects of an investigation.

In this research, quantitative research strategy (survey) was used to triangulate with and *facilitate* the qualitative research using the case-study based strategy. Author collected data in the first phase using a survey instrument and followed up with interviews in the second phase to conduct an in-depth investigation into the phenomenon of interest. *The author initial intention at the start of this research was to conduct a small survey in the first phase followed by detailed survey in the second phase of research. However, due to low response rate in the first phase of study discouraged the author to conduct a large scale survey in the second phase. The purpose of conducting a large scale survey was to develop a mathematical model using structured equation modelling. Due to low response, the author decided to conduct a detailed qualitative study in the second phase to answer the five RQs established at the outset of this research.*

Creswell and Clark (2007) suggested the use of visual diagrams to discuss the methods, procedure, and products of mixed methods studies. It is a useful tool to design and communicate the complexities inherent in the mixed-methods research. The author had used a visual diagram to explain the three phases of research using a mixed-methodology, as depicted in figure 5.2. The notation QUAN and QUAL are used to represent the quantitative and qualitative phase respectively.

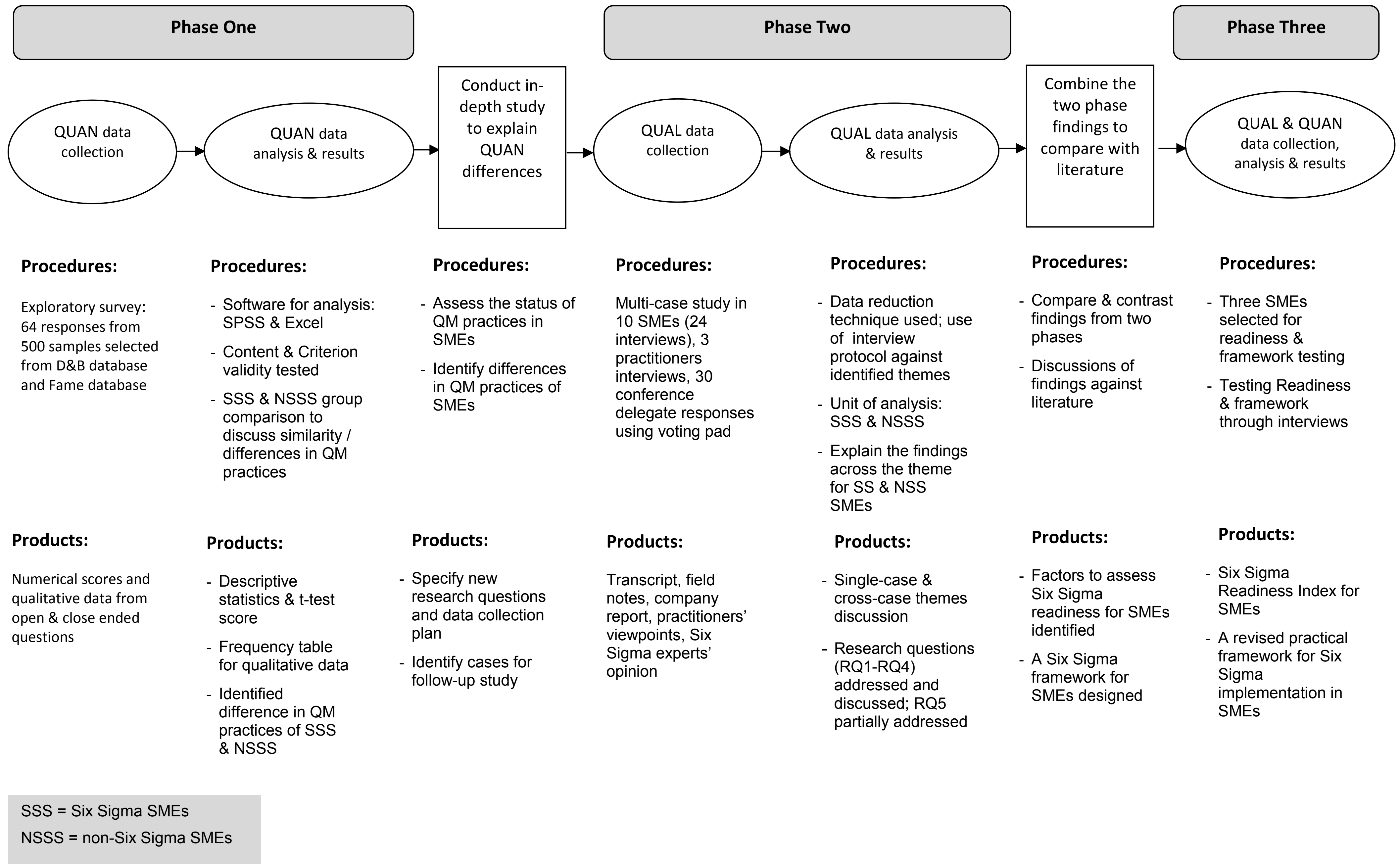

Figure 5.2: Visual presentation of the research design used by the researcher

The objectivity provided by quantification in the rationalist method combined with the qualitative understanding of the quantified factors may result in the theory building / enhancement process that offers greater potential for enhancing new theories than either methods alone (Meredith, 1998).

There is challenge in conducting a mixed - method research, in spite of its several advantages. The main issues were of time and resources required to collect and analyze the qualitative and quantitative data, and also training the researcher to have a good understanding of both methods of data collection (Creswell and Clark, 2007). In this research, the author had a good quantitative background and developed understanding of qualitative data analysis in the first year of his doctoral study. Attending several conferences, seminars at the university, and reading several qualitative method books facilitated in grasping the concept. Moreover, the author realised the value of mixed-method research that seems to outweigh the potential difficulty of this approach.

5.2.2. Survey

Survey research has contributed greatly to the advancement in the operations management area to study unstructured organizational problems and has been the most commonly used research strategy over the last three decades (Malhotra and Grover, 1998; Flynn *et al*., 1990; Meredith *et al*., 1989; Meredith, 1998; Voss, 1995; Forza, 2002, Rungtusanatham et al., 2003; Boyer and Swink, 2008). Kerlinger (1986) suggests that survey research is typified by the collection of data from a population, or some sample drawn from it, to assess the relative incidence, distribution and interrelationships of naturally occurring phenomena. Bryman (1988: 104) attempts a more formal definition: "*Survey research entails the collection of data on a number of units and usually at a single juncture in time, with a view to collecting systematically a body of quantifiable data in respect of a number of variables which are then examined to discern patterns of association*".

Quality management being one of the key areas of research within the operations management field, had also witnessed an explosion of survey based research in the last two decades. Researchers have used survey as the primary strategy to understand, assess, and resolve the issues in the area of quality management (Black and Porter, 1996; Badri *et al*., 1995; Flynn *et al*., 1994), TQM (Ghobadian and Gallear, 1996; Yusof and Aspinwall, 1999), Lean (Achanga *et al*., 2006; Yusuf and Adeleye, 2002), and Six Sigma (Antony and Banuelas, 2002; Antony *et al*., 2005, 2008). Survey research is the method of gathering data using an instrument composed of closed structure or open-ended items (questions). This is perhaps the dominant form of data collection in the social sciences, providing for efficient collection of data over broad populations, amenable to administration in person, by telephone, or over the Internet (Easterby-Smith *et al*., 2002; Saunders *et al*., 2007; Fowler, 2002).

5.2.2.1. Types of Survey research

There are three types of survey research, which have been used in the past to generate theory, test theory or extend an already existing theory/ theory refinement (Kerlinger, 1986; Malhotra and Grover, 1998; Forza, 2002). The first type can be classified as '*exploratory survey*', where the objective is to become more familiar by gaining preliminary insight into the phenomenon of interest and provide the basis for more in-depth survey. Even though the exploratory survey does not propose any models or hypotheses, it may help to determine the concepts to be understood and measured with respect to the phenomenon of interest and discover new facets of the topic of interest under study (Malhotra and Grover, 1998; Forza, 2002). The data collected through this research may be used to identify new possibilities and dimensions of interest or uncover evidence of association among concepts.

Another type of survey research is *'descriptive survey'* that is aimed at describing the distribution of the phenomenon in a population, thereby ascertaining facts. Hypotheses are formulated and tested related to common perceptions or changes over time, thus providing useful hints for both theory building and refinement (Malhotra and Grover, 1998; Forza, 2002). The third type of survey is the '*explanatory (or theory testing)'* survey research, used to explain the causal relationship between variables, testing the adequacy of pre-defined concepts and models in relation to the phenomena under study or testing the hypothesized linkages (i.e. positive, negative or no relationships exist) among concepts (Malhotra and Grover, 1998; Forza, 2002). It takes place when the knowledge about the phenomenon of interest already exists in terms of pre-defined concept, propositions, and models. Other critical differences between the three types of survey research are presented in table 5.2.

Table 5.2: Critical differences in the three types of survey research

Survey Type Element/Dimensions	Exploratory	Descriptive	Explanatory
Unit (s) of analysis	Clearly defined	Clearly defined and appropriate for the research questions/ hypotheses	Clearly defined and appropriate for the research questions/ hypotheses
Respondents	Representative of the unit of analysis	Representative of the unit of analysis	Representative of the unit of analysis
Research Hypothesis	Not necessary	Questions clearly stated	Hypotheses clearly stated and theoretically motivated
Representativeness of sample frame	Approximation	Explicit and logical argument to choose among alternatives	Explicit and logical argument to choose among alternatives
Representativeness of the sample	Not a criterion	Systematic, purposive, random selection	Systematic, purposive, random selection
Sample size	Sufficient to include the range of the interest phenomena	Sufficient to represent the population and conduct statistical analysis	Sufficient to test categories in the theoretical framework with statistical power
Pre-test of questionnaires	With sub-sample of the sample	With sub-sample of the sample	With sub-sample of the sample
Response rate	No Minimum	Greater than 50% of targeted population and study of bias	Greater than 50% of targeted population and study of bias
Data triangulation	Multiple methods	Not necessary	Multiple methods

(Source: Forza, 2002)

For the author's Doctoral study, an exploratory survey was used in the first phase of research to assess the quality management (QM) practices in UK manufacturing SMEs and to identify the adopters of Six Sigma and other quality initiatives or *certification systems. This facilitated in comparing the differences in QM practices between Six Sigma and Non-Six Sigma SMEs (the difference between the definition of Six Sigma and non-Six Sigma SMEs was explained in Chapter 6. Here we can assume that Six Sigma and non-Six Sigma firms are adopter and non-adopter of Six Sigma respectively). The identification of adopters and non-adopters of Six Sigma also aided in selecting SMEs for conducting multiple-case studies in the second phase of research. With Six Sigma research in SMEs being at its infancy, the exploratory survey was the way forward to understand the key QM practices in SMEs and* discover new facets of the topic of interest under study*. As discussed in section 5.2.1.1, this research espoused a mixed-method approach with survey (QUAN) being first part of research strategy followed by conducting multiple case-studies (QUAL) to answer the key research questions posed in Chapter 1.*

5.2.2.2. Sample Frame Selection

In any research, it is imperative to define the sample and the unit of analysis at the outset. The representativeness of any sample in a population depends on the sample frame, sample size, and the specific design of selection procedure (Fowler, 2002; Forza, 2002). In the case of SMEs, it is very difficult to get a comprehensive database including all UK SMEs due to the continual birth of small business or close-up of existing small businesses (Curran and Blackburn, 2001; Storey, 1994).

Before conducting the survey in summer 2007, author conducted a research on existing databases of SMEs and identified those organizations having the latest details of SMEs. The author contacted small business research centre at the *University of Warwick* and the *University of Cambridge* to enquire about the best commercial supplier of SME database. Up to and including 2007, these universities were actively involved in conducting survey research on SMEs. Given the reputation of these two universities and their research environment, their advice of procuring a database from Dun & Bradstreet (D & B) was taken into consideration. Nonetheless, other sources such as the DTI and Scottish Chambers of Commerce were also contacted to confirm the authenticity of D & B. In order to generate a comprehensive sample frame, the database from D & B was combined with a database generated from FAME. It took nearly two months to build up a database of 5000 SMEs after filtering and removing duplicate entries from both suppliers. The database of SMEs generated from the two suppliers lists were based on the following criteria:

- Fit the DTI definition of SME
- UK manufacturing companies only
- Representation from Scotland, England, Wales, Northern Ireland
- Micro Enterprise excluded from the list
- Contains a valid phone number, email-id, and website

The sampling design used to select the sample may be grouped into two categories- probabilistic (e.g. simple random sampling, systematic sampling, stratified random sampling) and non-probabilistic sampling (e.g. convenience sampling, judgement sampling, quota sampling). In this research, *a stratified random sample* of 600 SMEs was chosen from the comprehensive sample frame to conduct the pilot study and the actual survey. Stratified random sampling involves a random selection of ‘subject of interest’ from each strata identified from a population based on criteria such as size, type of industry, turnover, location, or others (Forza, 2002; Rungtusanatham *et al*., 2003). This sampling strategy ensures the homogeneity within each stratum and heterogeneity between strata. The strata defined to shortlist 600 SMEs from a randomly generated database of 5000 SMEs included the size of industry (small and medium-sized only) and the location of the industry (proportionate representation from Scotland, England, Wales, and Northern Ireland).

Clearly defining *the unit of analysis* for each set of information required was imperative. In most cases within quality management research, the unit of analysis is the plant or the company. As the plant or company cannot respond to a questionnaire, it was the individual working at different hierarchical levels (senior/middle management level) was carefully chosen, based on their knowledge about the subject of interest, to provide the requisite information about quality management practices in the company (Forza, 2002, Malhotra and Grover, 1998). *The survey instruments were targeted at Managing Director/ Operations Director/ Quality Manager/ Production Engineer working in the sample firms.* A postal survey was used as a data collection method for the pilot study and the actual survey and analyzed with the help of Microsoft excel 2007 and the statistical package for social sciences (SPSS) 15.0 version.

5.2.2.3. Questionnaire layout and field pre-test

Before designing the questionnaire, it is important to understand the different data collection methods existing within survey research. The selection of a single or multiple data collection methods in combination with the key research questions governed the design and contents of the questionnaire. Many data collection methods exist within survey research, ranging from postal survey, telephone survey, and internet survey to direct observation and face-to-face interviewing (Fowler and Mangione, 1990; Fowler, 2002). There are relative merits and demerits of each method, as demonstrated in table 5.3, and the choice of method(s) depends on its ability to capture the requisite information in answering the research aims and objectives.

Table 5.3: Data collection methods for survey research

Issues	Questionnaire			Interview	
	Post	*Drop-off*	*Internet*	*Personal*	*Phone*
Are Visual Presentations Possible?	Yes	Yes	Yes	Yes	No
Are Long Response Categories Possible?	Yes	Yes	Yes	???	No
Is Privacy A Feature?	Yes	No	No	Yes	???
Is the Method Flexible?	No	No	No	Yes	Yes
Are Open-ended Questions Feasible?	L*	No	L*	Yes	Yes
Can You Judge Quality of Response?	No	???	No	Yes	???
Are High Response Rates Likely?	No	Yes	No	Yes	No
Can You Explain Study in Person?	No	Yes	No	Yes	No
Is It Low Cost?	Yes	No	Yes	No	No
Are Staff & Facilities Needs Low?	Yes	No	Yes	No	No
Does It Give Access to Dispersed Samples?	Yes	No	Yes	No	No
Does Respondent Have Time to Formulate Answers?	Yes	L*	Yes	L*	L*
Is A Long Survey Feasible?	Yes	No	L*	Yes	No
Is There Quick Turnaround?	Yes	No	Yes	No	Yes

**L= Limited*

Telephone surveys and personal interviews are expensive and time-consuming to administer, but they permit clarification or explanation of items, reduce the number of blank or incorrectly completed items, and may increase the response rate. Self-administered surveys (Questionnaire survey), distributed by post or internet are less expensive to administer than in person or telephone surveys and can provide privacy and anonymity to respondents (Easterby-Smith *et al*., 2002; Saunders *et al*., 2007; Fowler, 2002). However, these surveys typically yield numerous unusable or incomplete responses and may require multiple mailings to obtain a response rate high enough to generalize the data gathered to the whole target population. *This problem is often encountered in the author's area of research.* Even though each type has some general advantages and disadvantages, there are exceptions to almost every rule.

In Quality management research, researchers mostly opt for postal surveys as the type of information required in the research area can be best gathered through a postal survey and it is less expensive than some other survey methods. Researchers in the past have used surveys to find CSFs in the implementation of CI programme, establishing relations between the use of quality tools and company performance, comparing performance of firms implementing CI programme and a non-implementer, to check the implementation status and effectiveness of any CI programme in an organisation, etc. (Flynn *et* al., 1994; Ahire and Golhar, 1996; Lee, 1998; Black and Porter, 1996; McAdam and McKeown, 1999; Yusof and Aspinwall, 1999, 2000a; Rahman, 2001; Antony and Banuelas, 2002; Antony *et al.*, 2005, 2008).

The author also selected a postal survey as a data collection method for the following reasons:

- Most commonly used data collection method while researching SMEs, though the average response rate was low
- Low cost and less time in conducting a postal survey compared to other methods such as face-to-face interview and telephonic surveys. There was limited fund available to conduct the research within the restricted time span.
- Contact details of quality manager/ operations director of SMEs were not readily available to encourage the use of other methods of data collection such as web-based surveys or personal interviews.

- Minimize the biasness in the result by sending the questionnaire to a randomly generated sample from a population rather than conveniently selecting SMEs know to the author and his research team.

The survey instrument was developed based on questionnaire used in the published literature of leading Six Sigma practitioners and academics (Antony and Banuelas, 2002; Ghobadian and Gallear, 1996, 1997; Lee and Oakes, 1995; Snee, 2004; Wessel and Burcher, 2004; Yusof and Aspinwall, 1999, 2000a,b,c; Antony *et al*., 2005; Kumar, 2007) and by means of a brainstorming session with a number of quality professionals within the UK, who were familiar with Six Sigma and other quality management philosophies such as TQM. The questionnaire for this survey, attached in Appendix II, was structured into three main sections.

Section 1 included demographic questions related to the type of firm (independent vs. part of MNC); size of the firm; annual turnover; type of manufacturing industry; position of respondent; information on quality initiatives in SMEs and related quality management practices such as the existence of a quality department; team for problem solving; review meetings; education and training for employees; company's strategic objective; understanding the voice of customer and winning customer loyalty. The last question in Section 1 was an open-ended question that asked SMEs reasons for not implementing Six Sigma. Control variables such as type of firm, size of firm, and type of quality initiatives were used to compare and contrast the differences existing in QM practices within variables of each control group. Section 1 provided a general overview of QM practices in UK manufacturing SMEs and facilitate in identifying adopters and non-adopters of Six Sigma. It also provided useful information as why SMEs were not embarking on Six Sigma. Section 1 was designed with a view to answer RQ2 and dispels the myth of non-applicability of Six Sigma in a SME environment.

The second section included information on 13 factors critical to the success of quality initiatives (QI) identified from table 3.3 (CSFs of CI initiatives in SMEs) and matched with the existing literature on Six Sigma implementation in SMEs (Wessel and Burcher, 2004; Deas, 2004; Antony *et al*., 2005; Kumar, 2007). The common factors listed in Six Sigma study and table 3.3 were extracted and incorporated in the survey instrument. The purpose of this section was to identify the importance of CSFs in the successful implementation of quality initiatives. CSFs were scored on a Likert scale of

1-5, *with 1 being not important to 5 being very important.* To measure the implementation level of the aforementioned CSFs in the participating SMEs, a Likert scale of 1-5 was used, where *1 is not implemented to 5 being fully implemented*. There was very limited conclusive support in the literature for choosing a five point rating scale over other rating scales like 3 points, 6 points, or seven points (Cooper and Schindler, 2006). Cooper and Schindler (2006) further suggested that no critical differences existed if a scale ranging from three to seven points was used. As said by Hasson and Arnetz (2005) – "*too many response categories may lead to difficulties in choosing and too few may not provide enough choice or sensitivity, forcing the respondent to choose an answer that does not represent the person's true intent*". A 5 point Likert scale seems to be the most popular choice in management and social science research (Cooper and Schindler, 2006; Bryman and Bell, 2007). The CSFs findings facilitated in identification of a gap in the participating SMEs with respect to the importance and implementation level of CSFs. The intention was also to test the difference in scoring of CSFs when compared across the control variables of type and size of SMEs, and type of QI implemented in the participating firm. This section also included information on the barriers encountered during implementation of quality improvement initiatives. Respondents were asked to identify the five important challenges they have faced in the implementation process.

The final section of the questionnaire asked about the benefits participating firms have experienced following the implementation of QI. The metrics identified from the literature review process were the most commonly cited/ used metrics within a SME environment. A Likert scale of 1-5 was used to measure the performance of participating firms, where 1 stands for negative benefit / improvement to 5 being crucial benefit / improvement in the measure after the implementation of QI. The performance metrics (9 factors) included in this section was divided into two groups of strategic and operational measures respectively (Kumar, 2007; Hvolby and Thorstenson, 2001; Beheshti and Lollar, 2003; Sila *et al*., 2005). The score of participating firms was used to compare the differences, if they exist, in the performance of Six Sigma and Non Six Sigma SMEs. Respondents were also asked about their understanding of cost of poor quality (COPQ) and what factors it encompasses. COPQ may be regarded as a criterion of quality performance, the measurement of which may lead to identification of hidden factory / waste in the organization (Dale *et al*., 2007).

The questionnaire was pilot tested with 100 SMEs from the sample for its content validity, i.e. the extent to which a measurement reflects the specific intended domain of content. A cover page introducing the key aims and objectives of the survey was attached with the questionnaire to explicate the rationale of study to SMEs (attached in Appendix II). The respondents were requested to provide opinions on the content of questionnaire, design of the questions, language usage, time to complete, technical contents and any other points missing in the questionnaire that was not addressing the research objectives. After receiving 15 responses (15% response rate) from UK manufacturing SMEs, some minor changes were made in Section 1 and Section 3 of the instrument. Three questions in Section 1 were redesigned and more explanation was provided in Section 3 to facilitate in completion of the questionnaire. Likewise, a few technical problems encountered by respondents were also rectified. Five questions were dropped from the instrument as it was not directly linked to the research objectives. All the changes were made in expectation of a better response rate. The pilot test helped in identifying redundant or poor questions and provided an early indication of the reproducibility of the responses.

The modified survey instrument was four pages long including the cover letter. The author intentionally designed a short survey to increase the response rate as the literature suggests poor response rates when conducting survey in SME environment (Ahmed *et al*., 2004; Sousa *et* al., 2006; Anderson and Sohal, 1999; Wright and Burns, 1998; Co *et* al., 1998; Spencer *et al*., 1994). As the survey was a part of the research strategy, the focus was more on enhancing the response rate from Six Sigma and Non-Six Sigma firms and understanding the basic QM practices in these participating firms. The revised questionnaire was sent to the remaining 500 SMEs in July 2007 targeting Managing Directors, Operations Directors, Quality Managers, and Production Engineers within the sample. A cover letter on the university letterhead explaining the purpose of the survey and why organization participation is important to the study, was attached along with a self-addressed return envelope and a tear-off non-response slip. Each survey pack was provided with a unique identifier number to track the non-responses and send a reminder message to the firm with a request for participation. Two reminders were sent to sample companies at an interval of three weeks and five weeks.

The author considered ethical issues while conducting the survey and remained sensitive to the impact of his work on those whom the author approached to help, those who provided access and co-operation and those affected by the result. Ethics, in context of the survey, refers to the appropriateness of your behaviour in relation to the rights of those who become the subject of your survey results, or are affected by it (Saunders *et al.*, 2007). The concept of informed consent while conducting a survey includes aspects such as assurance of anonymity and confidentiality of data or participants in future and respecting the respondent's privacy (Easterby-Smith *et al.*, 2002), which was righteously followed during the survey and analysis of the results. Integrity was maintained by the researcher during data collection and the analysis stage.

5.2.2.4 Response rate

Seventy-five questionnaires were returned after two reminders were sent to the sample SMEs with only sixty-four completed and usable responses. This resulted in a response rate of 12.8% (calculated based on actual usable responses to total number of questionnaire sent), which is considered an average response rate in researching manufacturing SMEs. A low response rate when conducting survey on quality management topics in SMEs was evident in the literature and this trend was prevalent across the globe (Ahmed *et al*., 2004; Sousa *et* al., 2006; Anderson and Sohal, 1999; Wright and Burns, 1998; Co *et al*., 1998; Spencer *et al*., 1994). Other details related to the survey response were presented in table 5.4. 10.2% (11) of the participating firm's response were not included for analysis due to incomplete filling of the questionnaire or not fitting within the definition of SMEs, i.e. having more than 250 employees, thus failing to qualify within SME category. The contact details of 12 sample firms were wrong or the contact person had moved from the company. 11.5% of the firm declined to participate in the survey for the following reasons as cited in the non-response slip: non-relevance of the research topic; work pressure; company's policy not to participate in surveys; lack of experience; and objection to a particular question appearing in the survey.

Table 5.4: Key facts from survey response

Quality Initiatives in SMEs survey	Key Facts from survey response
Completed and usable responses	64
Unusable responses	11
Wrong address / contact details	12
Declined to participate	58
No response	355
Total	**500**

In total, 355 SMEs did not respond to the request to participate in the survey. In a survey, it is equally important to study the non-responses to identify whether they are different from the respondents, leading to biasness in the result (Fowler, 2002; Forza, 2002). Non-respondents can therefore limit the generalisability of results. Ten firms from the non-respondent list were randomly selected and contacted by telephone to identify the reasons for their non-participation. Some key questions were asked to observe any discernable pattern in their responses. Two firms had a company policy of not participating in surveys and rest of the SMEs did not participate due to work pressure and limited time to respond to a survey. However, none of the SMEs had any objections about the content of the questionnaire. Finally, no differences were observed in the characteristics of participating and non-participating SMEs in the survey, which limited the biasness creeping in the analysis and results (though it is impossible to completely eliminate the biasness from the survey).

5.2.3. Case Study

The decision to choose from different research strategies depends on the three conditions (Yin, 20003:5):

- The type of research questions
- The extent of control an investigator has over actual behavioural events, and
- The degree of focus on contemporary as opposed to historical events

Adhering to the aforementioned point, Yin (2003:13) defines the case study as "*an empirical enquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident".* Meredith (1998) provided another definition for case study research especially in the context of operations management– "*A case study typically uses multiple methods and tools for data collection from a number of entities by a direct observer(s) in a single, natural setting that considers temporal and contextual aspects of the contemporary phenomenon under study, but without experimental controls, or manipulations*".

Case study research includes direct observation of a contemporary event over which the investigator has little or no control of behavioural events. However, it ensures systematic measurement of various outcomes and processes through using multiple sources of data [e.g. observations, interviews, and documentation] (Eisenhardt, 1989; Voss, 1995; Meredith, 1998; Yin, 2003). *The case study is also a useful strategy in the early phase of research, where there may be no previous work for guidance* (Meredith et al., 1989) *or where existing theories seems inadequate* (Eisenhardt, 1989).

Comparing the use of surveys (as discussed in the previous section) and case studies across the aforementioned conditions, it is reflected from table 5.5 that a survey is suited for answering 'who' and 'what' questions; and 'how' and 'why' questions are addressed using the case study strategy. If the research questions focus mainly on 'what' questions, then it is a justifiable rationale for conducting either an exploratory or descriptive survey or an exploratory case study. *Nonetheless, it does not limit the researcher to ask 'what' questions while conducting an exploratory case study* (Yin, 2003; McCutcheon and Meredith, 1993).

Table 5.5: Comparing survey and case study based research strategies

Method	*Form of research question posed*	*Requires control of behavioural events?*	*Having access and available resources*	Application in this research
Survey	Who? What? Where? How many? How much?	No	Yes	Yes
Case Study	How? Why?	No	Yes	Yes

(Source: Yin, 2003)

Both survey and case study can be used for *theory building, theory testing, or theory extension* to answer what, how and why questions; however the emphasis of the case study is more on theory building (answering how and why questions) and the survey method is more appropriate for theory testing or verifying existing theory (McCutcheon and Meredith, 1993; Meredith, 1998). McCutcheon and Meredith (1993) commented on the suitability of the case study approach to study unfamiliar situations, where there exists little theoretical background on the subject of interest.

Similarly in this research, there exists very little evidence in the literature on successful implementation of Six Sigma in SMEs. By conducting case-studies in the second phase of research, the researcher unravelled the key questions established in Chapter 1. Through the use of a case study based approach, author explored information on the following key issues: history of quality initiatives including success and failure stories; critical success factors and barriers to implementation; impact of quality initiatives on the performance of the company, to name a few. The first phase of research facilitated in identifying dichotomous and similar cases from the sample, which were selected in the second phase of research for in-depth investigation on quality management practices within two clusters- Six Sigma SMEs and Non-Six Sigma SMEs. A more detailed explanation of the case study design is discussed in the later part of this chapter.

5.2.3.1. Type of Case Study

Similar to survey research discussed in the previous section, case study may also take the form of *description, exploration or being explanatory in nature* (Yin, 2003; McCutcheon and Meredith, 1993; Voss *et al., 2002*). Case studies are often used to *describe* hitherto unexplored phenomena or to *explore* the subject of interest. Whether your research is descriptive, exploratory, or explanatory, depends on several aspects of design; the foremost important point among them being the type of research questions being asked by the researcher. As the research questions established in Chapter 1 were mostly 'what' and 'how' type, the chance of adopting an *explanatory case study approach* (where we are interested in establishing the cause & effect relationship between variables) was dropped.

The first phase of the research used an exploratory survey to identify the similarities/differences in quality management practices of two clusters- Six Sigma SMEs and Non-Six Sigma SMEs. The second phase of research also adopted an *exploratory case study* approach to uncover the aforementioned area of research and contribute to the theory development process, the details of which were presented in table 5.6. The findings from the exploratory case-study were used to develop propositions and hypotheses for further study/inquiry, as discussed in Chapter 10.

Table 5.6: Case study types and its link with this research

Purpose of the study	Research Question	Potential Research Strategy
Exploration Uncover areas for research and theory development	Is there something interesting enough to justify research?	In-depth case studies; Unfocused, longitudinal field study
Theory Building Identify/describe key variables Identify linkages between variables Identify 'why' these relationship exist	What are the key variables? What are the patterns or linkages between variables? Why should these relationships exist?	Few focused case studies In-depth field studies Multi-site case studies Best-in-class case studies
Theory testing Test the theories developed in the previous stages Predict future outcome	Are the theories we have generated able to survive the test of empirical data? Did we get the behaviour that was predicted by the theory or did we observe another unanticipated behaviour?	Experiment Quasi-experiment Multiple case studies Large-scale sample of population
Theory extension/ refinement To better structure the theories in light of the observed results	How generalizable is the theory? Where does the theory apply?	Experiment Quasi-experiment case studies Large-scale sample of population

Source: Adopted from Voss et al (2002) and Shamsuddin (2007)

Exploration leads to development of research ideas and hypotheses. The author's choice of an exploratory case study is further supported by the statement from Yin

(2003; p.30) - *"For yet other topics, the existing knowledgebase may be poor, and the available literature will provide no conceptual framework or hypotheses of note. Such a knowledge base does not lend itself to the development of good theoretical statements, and any new empirical study is likely to assume the characteristics of an "exploratory" study"*.

Reflecting back to table 5.6, this clearly shows a mixed method approach of exploration and theory extension / refinement being adopted by the author to achieve the research aim established at the outset of the research.

Each of the aforementioned types of case study can further be classified as single or multiple cases and embedded or holistic cases, giving rise to four different types of case study: *Single-holistic; single-embedded; multiple-holistic; multiple-embedded* (Yin, 2003). In the holistic design, the focus is at the systems level or global organization as a single unit of analysis. In the case of embedded design, there are multiple units of analysis within the same organization (e.g. different departments or functional groups) or subjects of interest. The s*ingle case* approach is preferred to test a well formulated theory; or when the case represents an extreme or unique case; or the case is a representative or typical case; or it is a longitudinal case (Yin, 2003). The single case sacrifices the generalizability of the findings. This limitation is tackled by conducting *multiple cases* that augments external validity and minimizes observer biasness (Voss *et al*., 2002; Yin, 2003). However, there are time and resource constraints in selecting larger samples for multiple case studies and this also affects the in-depth investigation of cases.

In this research, the author conducted *multiple – holistic case studies in ten UK manufacturing SMEs* to achieve theoretical or literal replication that leads to the *development of a Six Sigma Readiness Index and a Six Sigma Framework in the third phase of the research*. More details of sample selection and unit of analysis were provided in the next two sections.

5.2.3.2. Case Study Sample Selection

Defining the scope of research, directly linked to research questions, is imperative before sample selection. While exploring or building theory from case study, replication logic rather than sampling logic is used to predict either similar results [literal replication] or dichotomous results for predictable reasons [theoretical replication] (Voss *et al*.,2002; Eisenhardt, 1989; Miles and Huberman, 1994). In performing case study, the goal is to expand and generalize theory (analytic generalization). Here, the cases are not treated as 'sampling units' (as in survey, where statistical generalization is the preferred path) and the research is striving to generalize a particular set of findings to broader theory. Therefore, the preferred sample selection methods in case study are convenience sampling or purposive sampling. The chances of using a random sample of cases are minimal while conducting case study as the researcher focuses more on analytical generalization.

Commonalities and differences across the cases may facilitate in the theory development that incorporates a range of conditions thought to affect the outcome of the study (McCutcheon and Meredith, 1993). Pettigrew (1988) in Eisenhardt (1989) pointed out to choose polar cases or extreme situations so that the subject of interest is "transparently observable". The idea behind theoretical sampling is to select cases that are likely to replicate or extend the emerging theory (Eisenhardt, 1989).

There is no prescriptive rule for the number of cases deemed necessary or sufficient while conducting case study research. Nonetheless, Yin (2003) and Eisenhardt (1989) provided a rough guideline on the number of cases- minimum of two cases to six or more cases depending upon inclusion of both literal and theoretical replication cases. Eisenhardt (1989) and Meredith (1998) prescribed inclusion of 2 to 10 cases to achieve theoretical generalization. It is advisable to include similar/exemplar cases for literal replication and polar cases/ extreme cases for theoretical generalization. A quote from McCutcheon and Meredith (1993) summarises the discussion on case study samples- *"Although a large and diverse set of cases can aid in such generalization, so can a depth of understanding of a single case".* Though a case based research is time consuming and less generalizable, it offers excellence in establishing a foundation for follow-on research streams (Boyer and Swink, 2008).

Before commencing the sample selection for multiple case studies, selection criteria were established based on the key research questions established at the start of the research, the details were provided in table 5.7. In this research, the case study samples were selected from responses collected in the first phase of the research, i.e. survey. At the end of survey instrument, respondents were asked if they were willing to participate in the second phase of study, i.e. case study. Twenty-five out of sixty-four participating SMEs initially agreed to contribute to the second phase of research. It was not feasible and pragmatic to include all the 25 firms for case study due to time and financial constraints. Also, it was required to shortlist the firms that matched closely with the selection criteria established in table 5.7. As the survey was focused on UK manufacturing SMEs, all the 25 firms' qualified the 'sector' criteria set for case study sample selection. Due to very limited sample participation from Northern Ireland (2) and Wales (3) in the survey, it was logical to exclude samples from these two regions for further study. Thus the focus of the study in the second phase was only on SMEs located in Scotland and England. It was indispensable to include samples implementing Six Sigma and Non-Six Sigma firms for comparative cross-case analysis of QM practices across the two clusters. Special care was taken to include the other two criteria of size and type of firm within the two clusters (Six Sigma SMEs and Non-Six Sigma SMEs).

The analysis of the survey, discussed in Chapter 6, clearly identified the list of SMEs implementing Six Sigma and other quality initiatives and their impact on the performance of the firm. It was necessary to select similar/exemplar cases as well as polar cases from the sample of 25 firms for the literal/theoretical generalization. However, it was difficult to select SMEs fulfilling all the established criteria in the table.

Table 5.7: Selection criteria established to select the case study sample

Case Study sample selection criteria	Description of criteria
Location of firm	Scotland, England, Wales, Northern Ireland
Size of firm	Small firm (10-49 employees) ; Medium-sized firm (50-249 employees)
Type of Quality initiatives undertaken	SMEs implementing Six Sigma/Lean; Non implementer of Six Sigma (including TQM, ISO, British Retail Consortium (BRC), to name a few)
Type of firm	Independent local firm; part of MNC
Sector	Manufacturing only

After studying the characteristics of 25 firms, 13 firms were found suitable for case study and were contacted to negotiate access. Three firms declined to participate in the study due to work pressure and changes in management structure of the firm. The author managed to get access to 10 SMEs for further study. The description of the ten participating firm was provided in table 5.8. It was not in the author's control to have equal representation for each criterion, which is the most desirable case, due to the consent from very limited number of firms to participate in the study. Special care was taken to at least have one case within each criterion established. More information on the position of the respondents from the 10 participating firms is discussed later in the data collection method section.

Table 5.8: Characteristic of the participating firms in case study research

Case Study sample selection criteria	Participating firms distribution
Location of firm	Scotland - 6 England - 4
Size of firm	Small firm - 3 Medium-sized firm - 7
Type of Quality initiatives undertaken	SMEs implementing Six Sigma - 5 Non implementer of Six Sigma - 5
Type of firm	Independent local firm – 7 part of MNC - 3
Sector	Manufacturing only - 10

5.2.3.3. Unit of Analysis

The focus at the outset of case study should be on defining the unit of analysis, which many researchers have struggled to define clearly in the past (Yin, 2003; 22). The unit of analysis may vary from an individual person to departments, organizations, decisions, programs, the implementation process, and organizational change (Yin, 2003; 23). The selection of an appropriate unit of analysis is related to the research questions established at the commencement of the study. Ill-defined or fuzzy research questions may lead to the wrong selection of the unit of analysis and thus conducting a less focused case study.

In this research, the author is comparing the similarities/ differences in quality management practices and its impact on the performance of Six Sigma SMEs and Non-Six Sigma SMEs. Thus, the primary unit of analysis is two clusters, i.e. Six Sigma SMEs and Non-Six Sigma SMEs. The secondary unit of analysis includes 5 case study SMEs within the Six Sigma cluster and another 5 SMEs within the non-Six Sigma cluster.

5.2.3.4. Data Collection Method

Similar to the mixed-method approach, a triangulation of data collection methods to study a phenomenon of interest may be very useful in improving the researcher's judgemental accuracy as well as providing information for verification from several sources (Flynn *et al*., 1990). Common data collection methods used in case study research are: *historical archive analysis, direct observations, participant observations, interviews, questionnaires, and documentation*. The strengths and weaknesses of each method are presented in table 5.9. The procedure to collect data through each of the method discussed in the table must be developed and mastered independently to ensure the proper use of each source (Yin, 2003).

Table 5.9: Strengths and weaknesses of the data collection techniques

Source of Evidence	Strengths	Weaknesses
Questionnaire	• Very time efficient for researcher and respondents • Responses can be quantified for ease of analysis • Economical and yet considerable amount of data	• Data collection depends on respondents' goodwill; questionnaire design • Quantity of data collected is limited • No opportunity for clarification and deeper questions
Interviews	• targeted- focus directly on the topic • insightful-provide perceived causal inferences • Opportunity to clarify ambiguity • Effective for collecting large quantities of in-depth data. • Researcher is not required to spend long periods of time on site.	• Bias due to poorly constructed questions and also if interviewer is not consistent • Response bias • Inaccuracies due to poor recall • Interviewing is time consuming • Data analysis is time consuming • Requires the researcher to gain access to the knowledge and meaning of informants.
Direct Observation	• Reality- covers events in real time • First hand information helps to better understand and interpret the phenomena • Collect substantial data in short time span	• Time consuming • Sometimes disturbs the naturalness of the setting
Participant	• [*same as above for participant*	• [*same as above for participant*

Observation	*observations*] • Insightful into interpersonal behaviour and motives	*observations*] • Bias due to investigator's manipulation of events
Diary Records	• Get information from the perspective of the employee. • Very appropriate during data analysis and writing up stage	• Difficulty to analyse the data
Documentation	• Stable- can be reviewed repeatedly • Data can be traced back over time • Cost effective way to getting the data	• Documents may be limited and unavailable • Low reliability– reflects unknown bias of researcher • Sometimes difficult to get access
Archival Records	• [*same as above for documentation*] • Precise and quantitative • No manipulation of data is possible	• [*same as above for documentation*] • Accessibility restriction due to privacy reasons

(Adopted and Modified from: Barnes, 2001; Yin 2003:86; Martinez, 2003; Shamsuddin, 2007)

Interviews are considered the best method of gathering large amount of in-depth data in a short time span while conducting a case study (Marshal and Rossman, 1995; Easterby-Smith *et al*., 2002; Yin, 2003). Depending on the purpose of the research, the interview may take a structured format with specific questions for the interviewee or it can be a semi-structured, open-ended type to enable interviewees to expand on the topic they consider as important and to frame those issues in their terms to open up new lines of enquiry (Meredith *et al*., 1989; Barnes, 2001; Yin, 2003; Ates, 2008). The critical differences between structured interviews and semi-structured/unstructured interviews are presented in table 5.10.

Table 5.10: Differences between types of interviews

Structured interviews	***Semi-structured/ unstructured interviews***
Standardised pre-prepared questions to impose a structure	Flexible framework to open up new lines of enquiry
Easier to time and control the interview	More time consuming and chances to digress away from the topic of interest
Suitable for less experienced interviewer	Need for experienced interviewer who can hold an interesting conversation during the interview
Comparable data	Can be difficult to compare the results
Difficult to follow-up point of interest or emerging themes	New points or emerging themes are followed up

(*Source: Yin, 2003; Ates, 2008*)

Semi-structured interviews (at the company site) were used as the primary data collection method in conducting multiple case studies in the selected SMEs. The research questions and findings from the first phase of study facilitated in developing the interview protocol (with established themes) for conducting semi-structured interviews in the second phase. The protocol included information on the purpose of the case study (already discussed in section 5.2.3), data collection procedures (discussed below), the theme identified for interview with questions included for each theme (Yin, 2003). *The themes identified for interview, as presented in figure 5.3, were focused on demographic details of firms, history of quality initiatives in the firm, quality management practices, CSFs and barriers to implementation, performance metrics used, readiness assessment for Six Sigma implementation, and differences between SMEs and large organizations*. For more information, please refer to the detailed interview protocol / questionnaire attached in Appendix III.

Themes	• ***Topic explored during interview***
Demographic details	• Size/Type/Location of firm • Products manufactured
Understanding Quality Management Practices in SMEs	• History of quality initiative(s) • Motivation to embark on quality initiative(s) • Framework /models/ roadmap used • Organizational infrastructure • ISO foundation to embark on Lean or Six Sigma • Quality tool & techniques used
Critical sucess factors (CSFs) & Barriers	• CSFs facilitating implementation • Challenges & impediments faced by SMEs
Performance Measures	• Performance metrics used • Improvement in metrics (soft & hard metrics) after implementing quality initiative(s)
Readiness for Six Sigma	• Key ingredients or factors that should be present in SMEs before embarking on Six Sigma
SMEs vs. Large firm	• Difference between SMEs & large firm w.r.t quality management practices • Relation between growth model & QI implementation

Figure 5.3: Interview Protocol used for case study data collection

At least two employees were interviewed in each case study company with a maximum of four interviews in two case study firms. *Twenty-four semi-structured interviews were conducted in the ten case study firms, with each interview lasting for approximately ninety minutes*. *The position of the interviewees ranged from top management level to middle level management, including Managing Director to Operations/ Quality Manager, HR manager, Production/ Quality Engineer*. Shop-floor employees were excluded from the interview process as the focus of the research was more on the implementation issues of quality initiatives, framework used for implementation, CSFs and barriers encountered during implementation, performance improvement after implementation, to name a few. Semi-structured interviews were the preferred method over the structured interviews to enable the generation of new ideas and leading questions through open discussion with the interviewees.

Data collection through interviews was enhanced by digitally recording the data rather than meticulously taking notes that may result in loss of information. On-site interviews facilitated data triangulation by collecting supplementary data through non-participant observations at the company site and archival records that the company had on its performance over the last few years. Participant observations in this case were not a feasible option due to time and financial constraints. Interviewing multiple respondents in an organization helped data triangulation through comparison of reports and interpretation of various respondents transcript.

Some information on quality management practices in SMEs, CSFs and barriers to implementation information was captured in the first phase of research through questionnaire. The author’s intention in the interview was to capture the data on the same theme without providing a structured questionnaire. This will minimize the response biasness on the part of the interviewee and information gathered would better reflect the original thoughts of respondents.

Apart from 24 interviews in 10 case study SMEs, *three more interviews* were conducted with the quality management/ Lean Six Sigma practitioners from the Manufacturing Advisory Services (MAS) in England, Manufacturing Institute (MI), and Scottish Manufacturing Advisory Services (SMAS) to get an actual picture on the status of quality management practices in SMEs. The reason for selecting practitioners from was due to the following reasons:

- MAS/MI/SMAS are government funded bodies established for helping SMEs to improve their business processes and performance
- Practitioners involved in these bodies have experience in conducting diagnostic testing to resolve quality related issues in SMEs by providing solutions for process improvement. The selected interviewees had an experience of resolving quality issues in more than 100 SMEs.
- Being involved in day to day activities of SMEs, these practitioners may provide a more accurate picture on the current status of quality management practices; impact of initiatives like Lean and Six Sigma on the business performance; challenges and barriers faced by SMEs in implementing different quality initiatives; quality tools & techniques used by SMEs, to name a few.

To answer the RQ5 on Six Sigma Readiness Index, data was also collected from delegates attending the 3rd International Conference on Six Sigma in Edinburgh on 15th -16th December 2008. Thirty delegates (including Six Sigma experts such as Prof. D.C. Montgomery and Dr. Roger Hoerl and other delegates from industry and academics across the globe) attending the workshop on 'Six Sigma for SMEs', delivered by the author and his Director of Studies, were asked to rank the top six out of ten CSFs (identified from the first two phases of the doctoral study), using an electronic voting pad, that they considered important and should be present in any organizations before they embark on the Six Sigma journey.

5.2.3.5. Qualitative Data Analysis

Qualitative data analysis could be linked to completing a jigsaw puzzle in which the pieces represents the data (Saunders *et al*., 2007). Analysis of large amount of information gathered through interview is the biggest challenge in qualitative research (Yin, 2003; Eisenhardt, 1989). The challenge faced by the researcher is how to condense the rich data into a format that could be convincingly comprehended by a target audience (Easterby-Smith *et al*., 2002). As stated by Eisenhardt (1989)- "*Analyzing data is the heart if building theory from case studies but it is both the most difficult and the least codified part of the process*". Miles and Huberman (1994) provided logical guidelines for qualitative data analysis and suggested several techniques for data presentation and analysis. Their proposed methods are being used to date by qualitative researchers for data analysis.

Several methods for qualitative data analysis have been proposed to date that includes content analysis, grounded theory, cognitive mapping, repertory grid, protocol analysis, pattern matching, critical incident techniques to name a few (Easterby-Smith *et al*., 2002; Miles and Huberman, 1994; Yin, 2003). Content analysis and pattern matching are widely cited techniques for qualitative data analysis (Saunders et al., 2007; Easterby-Smith, 2002). Content analysis facilitates in accepting or rejecting a priori hypothesis by identifying causally linked variables. Similarly, pattern matching is used in explanatory or descriptive case studies to establish causal relationships between variables, thus ensuring internal validity (Eisenhardt, 1989). The software packages such as NVIVO, NUD.IST, CAQDAS are also becoming popular for coding, generating patterns from large amount of narrative texts collected from open-ended interview or from historic documents (Yin, 2003). Two of the other most commonly used and cited techniques for qualitative data analysis are - a three step proposal by Miles and Huberman (1994): data reduction; data display; and drawing conclusions; and a two step process proposed by Eisenhardt (1989): within- case analysis and cross-case analysis.

In this study, no priori hypothesis was proposed or attempt made to identify causal relationship between variables. The focus here was more on exploring and understanding the quality management practices within two clusters, i.e. Six Sigma SME and Non-Six Sigma SME and developing ideas/ generating hypotheses for further research rather than establishing relationships between variables. Thus, content analysis and pattern matching was not adopted for data analysis in this research. This also resulted in not using software packages for generating patterns. Other reasons for not using software packages for analysis were- interview protocol with roughly identified themes were developed beforehand to facilitate data analysis; and also data collected through interviews were manageable to transcribe, document & display using the established theme within the interview protocol. The *author has used the three step technique proposed by Miles and Huberman (1994) and the two step process proposed by Eisenhardt (1989), which is simple, comprehensive, and most widely cited, for analyzing the interview data collected from the 10 case studies. The aforementioned techniques were briefly presented below.*

5.2.3.5.1. Data reduction

It is the first step in qualitative data analysis, where the researcher is required to sharpen, sort, focus, discard, or organize data, accumulated through written-up field notes or transcription, to draw a final conclusion and verify it (Miles and Huberman, 1994). It involves activities such as written summaries of cases, coding, generating themes, making cluster or partitions, to name a few. *In this research, the author generated case study reports/ summaries based on themes identified in interview protocol. The documentation of each case was done after each company visit so that no important information or data was lost.*

5.2.3.5.2. Data display

Miles and Huberman (1994) define display as *"an organized compressed assembly of information that permits conclusion drawing and action"*. The data display helps the audience to understand things happening within or across cases, based on which some further actions could be taken. Few methods of data display suggested by Miles and Huberman (1994) are charts, matrixes, tables, grid, and networks. *Charts, matrixes, and tables were used as a data display techniques to present the qualitative data collected in the second phase of research.* For more information on data display technique, refer to Chapter 7 and Chapter 8.

5.2.3.5.3. Data analysis and drawing conclusions

Data analysis is the next step once the researcher has identified the methods of data display. Within-case analysis is the next step in analysis followed by cross-case analysis of participating case study firms. In *within-case analysis*, detailed write-ups (case-study reports) are used to gain familiarity with each case as a stand-alone entity (Eisenhardt, 1989). This facilitates in identification of key themes and unique findings emerging from each case which could be used later in cross-case analysis to compare and contrast findings across cases. Within-case analysis familiarises the researcher with individual cases that further accelerates the cross-case analysis. In *cross-case analysis*, the author compares the findings across the cases with respect to categories or dimensions identified during the data reduction process or using the themes developed in the interview protocol for comparison across cases. It looks into similarities and differences between cases. It also enhances the external validity or generalisability of the research findings (Voss *et al*., 2002). A minimum of two samples are required for cross-case comparison. Based on within-case and cross-case analysis, conclusions are drawn related to the research questions posed.

The case study design used in this study was multiple-holistic approach (discussed in section 5.2.3.1) and primary unit of analysis was the Six Sigma firms and the non-Six Sigma firms (discussed in section 5.2.3.3). Based on the above design and unit of analysis, a within case analysis was conducted in the two clusters- Six Sigma firms and non-Six Sigma firms. Within each cluster, cross–case analysis was conducted across the five firms of each cluster. Cross case analysis was also conducted between the clusters and findings were presented in Chapter 8.

5.2.3.6. Ethical issues

Ethics, in the context of research, refers to the appropriateness of your behaviour in relation to rights of those who become the subject of your work, or are affected by it (Saunders *et al.*, 2007). The nature of business and management research is such that one will be dependent on other people for access and the closer the research to actual individuals in real world settings, the more likely are the ethical questions to be raised.

Activities such as gaining access to companies, interviewing some employees, documenting observations on-site were the key ethical issues involved in the author's doctoral research. An initial contract was agreed between the author and interviewees before the commencement of each case study on maintaining the anonymity and confidentiality of data, interviewees, and the companies in the future. During interview, it was kept in mind that questions were structured in a way that does not invade the privacy or hurts the sentiment of the interviewees. It was also agreed to maintain the anonymity of the respondent / company during reporting the results. Interviewees were also requested to review the case study report after transcription of the interview data to agree on the content of the report. After receiving the comments and consent from interviewees, reports were revised and used for data analysis. Interviewees provided their consent that any findings from the case study are publishable in a journal or magazine, provided the company /respondent was not readily identifiable.

5.2.4. Methodology used in the third phase of research

The findings from the first two phases were used in conjunction with literature to develop a Six Sigma Readiness Index (that assesses SMEs readiness to embark on Six Sigma journey) and a practical framework for Six Sigma implementation in SMEs. *The index and the framework was tested in three SMEs (selected from case-study sample- two implementing Six Sigma and another non implementer of Six Sigma) by conducting interviews with six respondents (at middle management level) from the three firms and seeking their viewpoints on the proposed index and framework*. The suggestions from the interviewees were used to revise the index and framework. *Other types of research strategies not used in this research are briefly discussed in the next four sections.*

5.2.5. Experiment

Experiment is used to understand the causality in the quantitative research or positivist paradigm, ensuring internal validity (Bryman and Bell, 2007; Saunders *et al*., 2007). Experiment is not a common strategy within operations management research simply because of the problem of achieving the requisite level of control in the operations of the real world organization (Meredith *et al*., 1989). Some typical experimental designs are

- *Classical experimental design*: where the experimental group receives treatment and compared against a control group (which does not receive any treatment) with regard to a dependant variable.
- *Laboratory experiment:* where the researcher has greater influence over the experimental arrangements that may enhance the internal validity of the study as compared to field experiments in real-life organizations. It is also easier to replicate due to a greater control over the experiment.
- *Quasi-experiment*: in such experiments, it is not possible to randomly assign subjects to experimental and control groups.

5.2.6. Grounded Theory

Grounded theory (GT) was discovered by Glaser and Strauss in 1967 to develop theory from the data generated by a series of observations/fieldwork in the process of conducting research (Saunders *et al*., 2007). Though the strategy follows the inductive approach, the data collection methods used to generate theory may be the combination of qualitative or quantitative research. GT investigates the actualities in the real world and analyses the data with no preconceived hypothesis (Glaser & Strauss, 1967). In the GT data analysis, concepts are searched for behind the actualities by looking for *codes*, then *concepts* and finally *categories*. This strategy requires a steady movement and comparison between concept and data, and also requires a continuous comparison across the types of evidence to control the conceptual level and scope of the emerging theory (Rowlands, 2005). Other key features of GT are (Ates, 2008):

- GT focuses on how individuals interact in relation to the phenomenon under study
- Data analysis starts immediately after first set of data is collected
- The emerging concepts from the data analysis decides upon the further collection of data
- Data collection stops when no new conceptualization emerges

5.2.7. Ethnography

Ethnography emanates from the field of anthropology and follows an inductive approach to research (Saunders *et al*., 2007). A popular definition of ethnography is found in Hammersley and Atkinson (1995: 1), who write of ethnography, *"We see the term as referring primarily to a particular method or sets of methods. In its most characteristic form it involves the ethnographer participating, overtly or covertly, in people's lives for an extended period of time, watching what happens, listening to what is said, asking questions—in fact, collecting whatever data are available to throw light on the issues that are the focus of the research"*. The purpose of ethnographic study is to interpret the cultural understanding of the population under study in the way in which they interpret it. This increases the chance of biasness in the way researchers comprehend the interpretation. While not inherent to the method, cross-cultural ethnographic research runs the risk of falsely assuming that given measures have the same meaning across cultures.

5.2.8. Action Research

Kurt Lewin, in 1946 first coined the term “action research” (Saunders *et al*., 2007), defining action research as *“a comparative research on the conditions and effects of various forms of social action and research leading to social action” that uses “a spiral of steps, each of which is composed of a circle of planning, action, and fact-finding about the result of the action”.* Since then, it had been interpreted in several ways by management researchers. Eden and Huxham (1996) commented on the role of action research in the theory building process, in which theory develops from the analysis and synthesis of the data generated from a series of events as the designated issue is confronted by the researcher (Coughlan and Coghlan, 2002), who is part of organization within which the research and change process are taking place. Theory generated through action research is specific to the context of action and is not aimed at creating universal knowledge. The key differentiator between action research and other strategies is its focus upon resolving issues and bringing change; aims at solving problems and contributing to science; focus on holistic and contextual understanding of phenomena; facilitate incremental theory building; and generalization takes place through conceptualization of a particular experience and linking to the theory (Saunders *et* al., 2007; Clough and Nutbrown, 2002; Mendibil, 2003, Lopez, 2005, Shamsuddin, 2007).

5.2.9. Rationale for the choice of Research Strategy

Experiment was not used in this research due to the control required to conduct the research and also because focus of this study was not to establish the causal relations between factors, which is the key objective while conducting an experiment. Grounded theory was not used as the author was using the already established theme to capture the viewpoints of interviewees rather than collecting data and trying to identify emerging concepts. Grounded theory may be used to study data from an exploratory case study and to drive data collection activities within and outside the case study. Ethnography research was not used as it is often time consuming and takes place over an extended time period. As the objective of the study was only to understand the quality management practices in Six Sigma and non-Six Sigma firms through use of questionnaire and interviews; no attempt was made to bring any changes in the practices of the participating firms, which is the goal of the 'action research' approach. Hence action research was also not the preferred method for this research. After briefly discussing each strategy and its characteristics, it can be said that mixed method approach of survey and case study was best suited to address the key research questions within the given time period and available resources. The survey provided the general view of quality management practices in SMEs and the case-study gave an opportunity to conduct an in-depth investigation into the phenomenon of interest using data collection techniques such as the '*questionnaire, interviews, observation and documentation'*.

5.3. Criteria for judging the Quality of Research Design

This section explains the research quality criteria used during the research design to establish the quality of this research, i.e. ensure the reliability and validity of this research and also to explicitly demonstrate the contribution made to the theory and practice of Six Sigma in the SME environment. The six quality criteria identified through the literature review process (Miles and Huberman, 1994; Stake, 1995; Meredith, 1998; Easterby-Smith *et al*., 2002; Voss *et al*., 2002; Yin, 2003; Ates, 2008) to establish the quality of this research are

1. Construct Validity
2. Internal Validity (for case study) / Content Validity (for survey)
3. External Validity / Generalisability
4. Reliability
5. Contribution to theory / knowledge
6. Contribution to practice

Measurement quality refers to the reliability and validity of the measurement instruments used to collect data, particularly in the case when the researcher is seeking to test relationships among constructs using multi-item measures of a variable (Rungtusanatham *et al*., 2003; Malhotra and Grover, 1998; Voss *et* al., 2002, Yin, 2003). Reliability is concerned with the stability and consistency in measurement, while validity is concerned with whether the right concept is being measured (Forza, 2002; Miles and Huberman, 1994; Saunders *et al*., 2007; Voss *et al*., 2003; Yin, 2003). The literal meaning of the reliability and the validity tests are similar for survey and case study approach, though the tactic used to address each criterion may vary for case study research (as shown in table 5.11). Theoretical contribution refers to the ability of research to link with theory (Yin, 2003; Easterby-Smith *et al*., 2002), whereas practical contribution refers to usefulness, functionality, practicality of research and how it has served the purpose (Miles and Huberman, 1994).

Table 5.11: Reliability and validity in case research

Test	Case Study Tactic	Phase of research in which tactic occur
Reliability	▪ Use case study protocol	▪ Data collection
	▪ Develop case study database	▪ Data collection
Construct validity	▪ Use multiple sources of evidence	▪ Data collection
	▪ Establish chain of evidence	▪ Data collection
	▪ Have key informants review draft case study report	▪ Composition
Internal validity	▪ Do pattern-matching	▪ Data analysis
	▪ Do explanation-building	▪ Data analysis
	▪ Address rival explanations	▪ Data analysis
	▪ Use logic models	▪ Data analysis
External validity	▪ Use theory in single-case studies	▪ Research design
	▪ Use replication logic in multiple-case studies	▪ Research design

(Source: Yin, 2003, p. 34)

This research embraces a triangulation approach at both methodological level and data collection level to enhance the reliability and validity of research. The data analysis technique used for this research, i.e. data reduction (enhances reliability of data collection and construct validity), data display (enhances internal validity of analysis), within case analysis (internal validity of analysis), and cross-case analysis (enhances the potential of generalization of the research findings) further enhanced the quality criteria of reliability and validity for this research (Yin, 2003; Voss *et al*., 2002). Chapter 10 includes discussion on how each of the aforementioned quality criteria in table 5.11 was addressed in this doctoral research.

5.4. Summary

Research design not only governs the use of appropriate research strategy and data collection methods but also the findings and type of conclusions drawn from this research. Therefore, it was imperative for the author to clearly understand the concept of research design and its impact on the findings of the research. This chapter included discussion on different research strategies and data collection methods and *provides justification for the choice of the mixed method approach of survey and case study for this research*. Table 5.12 links the use of different strategies to answer the research questions. The data collection methods used for this research included survey questionnaire, semi-structured interviews in case study firms along with company reports and data collected through on-site observations.

Table 5.12: Link between research question and research strategy

Research Questions	***Strategy***	***Data Collection method(s)***	***Where in the thesis?***
What makes SMEs different from large organizations?	Case Study	Interview protocol	Ch 2, 7, 8
What are the critical differences in quality management practices of Six Sigma and non-Six Sigma SMEs?	Survey Case Study	Interview protocol, Observation, Questionnaire	Ch 6, 7, 8
What are the critical success factors and barriers to implementation of Six Sigma in SMEs?	Survey Case Study	Interview protocol, Observation, Questionnaire	Ch 6,7,8
Does the performance of Six Sigma firms differ from non-Six Sigma firms?	Survey Case Study	Interview protocol, Observation, company report, Questionnaire	Ch 6,7,8
How to assess the readiness of a SME to embark on Six Sigma journey?	Case Study Viewpoints of attendees in an International Conference	Interview protocol, Voting Pad	Ch 7,8, 9

The chapter also included discussion on design of survey instrument and interview protocol; sample selection criteria for survey and case-studies; and research quality criteria to establish the quality of this research. This chapter provides the base for conducting data analysis in Chapter 6, 7, 8, and 9.

Chapter 6
Survey Data Analysis

6.0. Introduction

This chapter presents finding from an exploratory survey conducted in the UK manufacturing SMEs. The purpose of the survey was to identify critical differences, if it exists, in the quality management (QM) practices of Six Sigma and Non-Six Sigma SMEs. Analysis of survey instrument provided greater understanding of the quality management practices in SMEs and identified firms implementing different quality initiatives such as Lean, Six Sigma, TQM, Kaizen, or certification system like ISO 9000 or Investors in People. The data analysis was conducted in SPSS 15.0 and excel worksheet and the results were primarily based on descriptive statistics. However, the application of inferential statistics was not precluded from the analysis and was used at several places to statistically identify and validate the degree of correlations or association between different variables. The output / findings from this phase of study were used as an input to the second phase of research when conducting multiple-case studies in *ten SMEs* identified from the survey responses.

The next section presents findings from the survey with major focus on following themes: demographic information; quality management practices in different type/size of SMEs; critical success factors (CSFs) and barriers to implementation; and impact of quality initiatives on performance of SMEs.

6.1. Demographic Information

The demographic details pertaining to samples companies includes information on the type of firm (local, joint venture, or the part of multi-national corporation [MNC]); location of the firm within the UK; type of manufacturing industry which includes 13 categories; size (small or medium); annual turnover ranging from less than £1 million to over £50 million; and position of the respondents including CEO/ Managing Director, departmental head, quality manager and others. For more information about the questionnaire, please refer to Appendix II. These variables may also be termed as control variables, used in later part of analysis to understand the QM practices within sample firms. Variables such as *type and size of firm* provided useful information as whether there were any significant differences in working culture and business practices of a local firm as compared to a firm being part of MNC or small firms in comparison to medium-sized firms. Moreover, it also provided useful information on the representation of sample across the country to minimize the element of biasness with respect to the location of the firm. The analysis of demographic details of aforementioned variables from the survey instrument was discussed below.

Among the 64 responding SMEs, 49 firms (76.56%) were independent local firms, 14 (21.88%) firms were part of MNC and one being a joint venture company. Geographically, majority of the SMEs were located UK wide (43 or 67.1%) as depicted in figure 6.1. SMEs located UK wide had production site at one location and other support processes such as marketing and sales, customer service located nationally. Some of these firms were also part of MNC, operating at different locations within the UK and having diversified businesses such as automotive, aerospace, telecommunication, etc to name a few.

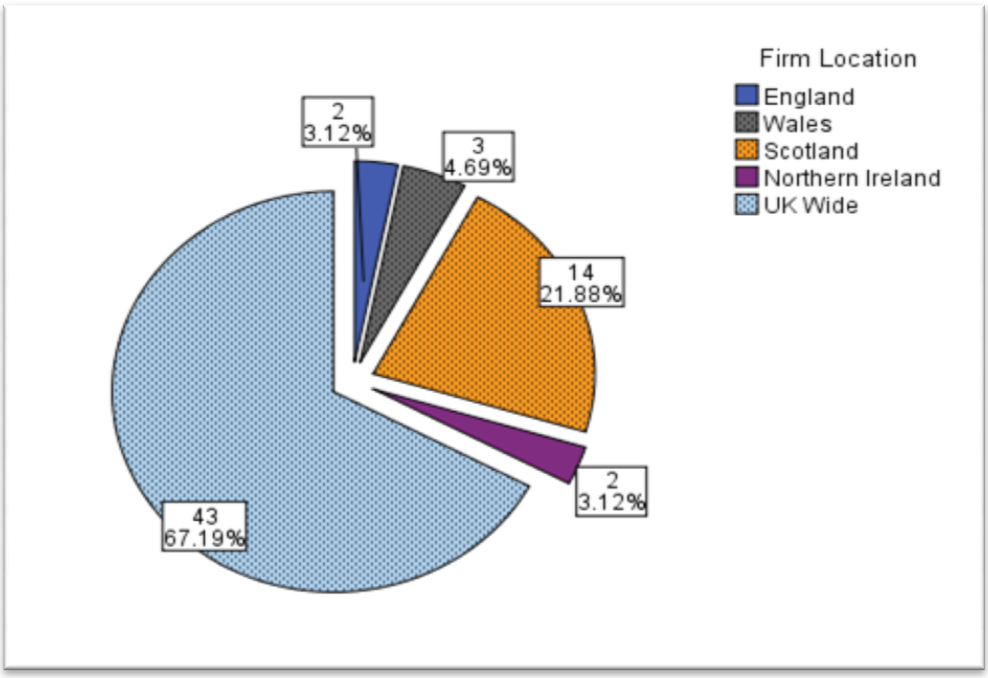

Figure 6.1: Location of sample SMEs within UK

The distribution of 64 manufacturing firms in different type of industry was presented in table 6.1. It can be gauged from table 6.1 that the sample was representative of different kind of manufacturing companies ranging from aerospace, automotive, electronics and semiconductors to food, paper and plastic manufacturing industry. The other category includes manufacturer of window blinds, packaging materials, cosmetic and toiletries; construction equipments and tools (3); and oil & gas (4).

Table 6.1: Industry Specialization of sample firms

Industry specialization	Count
Automotive	3
Textiles	3
Chemical	5
Aerospace	3
Electrical	7
Pharmaceuticals	3
Printing/paper	5
Mechanical	6
Food	7
Electronics & Semiconductor	8
Others	14

One of the control variables included in the survey was size of the company, i.e. small (< 50 employees) and medium-sized company (50-249 employees). Twenty five percent of the respondents were in small firm category and seventy five percent belonged to medium-sized category. This variable facilitated in exploring the relationship between size of the firm and its impact on organizational performance. A clustered bar chart was plotted for size of the company against its annual turnover, as shown in figure 6.2. Out of 64 companies, 4 companies were not happy to discuss their annual turnover and thus not plotted in the chart.

The figure shows that there was significant variation in annual turnover within each sub group (small and medium). In order to prove it statistically and test whether there was any association between size and annual turnover of the company, a chi-square test was performed at 5% significance level.

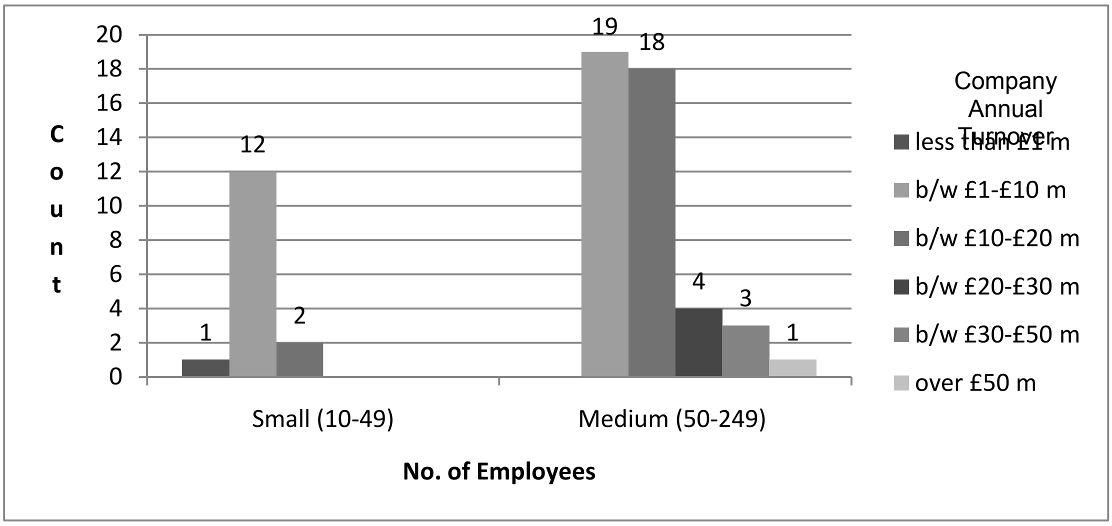

Figure 6.2: A clustered bar chart plot of size against company's annual turnover

The hypothesis proposed was

H_0: There is no association between size and annual turnover of the firm (Null hypothesis)

H_1: There is significant association between size and annual turnover of the firm (Alternate hypothesis)

The p-value in the table 6.2, i.e. 0.043, was less than 0.05, resulting in the rejection of null hypothesis and acceptance of alternate hypothesis. Hence, the chi-square test implies that there was significant association between the size and annual turnover of the firm. The smaller the firm in terms of number of employees, the lesser is the annual turnover of the company.

Table 6.2: Chi-Square test between size of firm and its annual turnover

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	11.174(a)	5	.043
Likelihood Ratio	13.096	5	.022
Linear-by-Linear Association	7.965	1	.005
N of Valid Cases	60		

6.2. Quality Management Practices in SMEs

6.2.1. History of Quality Initiatives in SMEs

The respondents were asked to list the quality initiatives implemented in the past or currently implemented in the firm. As depicted in table 6.3, majority of SMEs had ISO certification in place followed by implementation of Lean, Investors in People (IIP) and Six Sigma. Some of the SMEs had listed the implementation of two to three quality initiatives in the past. *The average duration of implementation of Lean or Six Sigma in SMEs was 4 years* that clearly indicates its limited application in a SME environment.

Table 6.3: History of quality initiatives in SMEs

Quality Initiatives Undertaken	Count	%
Six Sigma	10	15.6%
TQM	5	7.8%
Lean	23	35.9%
Kaizen	7	10.9%
Business process re-engineering (BPR)	1	1.6%
Theory of Constraints (TOC)	1	1.6%
ISO 9000	49	76.6%
Investors in People (IIP)	10	15.9%
European Foundation for Quality Management (EFQM)	0	0%
Others	9	14.3%
No initiative undertaken	8	12.5 %

Majority of firms that have embarked on the bandwagon of Lean and Six Sigma had gone through the route of ISO certification in past. Further in-depth analysis revealed that 17 out of 23 (approximately 74%) Lean firms had ISO 9000 certification in place before embarking on Lean Journey. Another interesting outcome of the analysis showed that 10 of these 17(59%) Lean firms have embarked on Six Sigma. This analysis gives an indication that *ISO may be the foundation or building block before embracing Lean and Six Sigma*. This trend had emerged from the analysis, though it was not the key focus of this study. To add validity to the aforementioned statement, i.e. *ISO as a foundation to embark on Six Sigma*, author decided to further investigate the aforementioned statement during the second phase of the study, i.e. while conducting multiple case studies within selected SMEs.

No SMEs in the sample have implemented the European Foundation for Quality Management (EFQM) assessment model, which further confirms the argument in the literature that *EFQM was not suitable for SMEs*. From the analysis, it was found that 8 (12.5%) responding firms do not have any kind of quality improvement methodology or systems in place. The focus in these firms was more on meeting the productivity targets and customers' delivery deadline. Majority of the respondents in the other category were implementing British Retail Consortium (BRC) certification, especially within the food industry.

In the analysis to follow, two categories were formed based on the type of quality initiatives in SMEs. In the category one was included firms implementing the following quality initiatives: Six Sigma and ISO certification; Lean only; Lean and ISO certification; Lean, ISO, and Six Sigma. Second category included firms that were implementing other initiatives or certification system such as TQM, ISO 9000, Kaizen, BPR, TOC, or initiatives in other category such as BRC. The category one was renamed as Six Sigma SMEs (SSS) and category two as non-Six Sigma SMEs (NSSS) for conducting analysis in the sections to follow. The rationale behind combining Lean and Six Sigma SMEs in one category was due to the similarity in performance of firms implementing either/ both initiatives. Moreover, the analysis of QM practices in both firms (such as winning customer loyalty, knowledge transfer mechanism, company strategic objective, customer focused measures, to name a few) yielded similar results with respect to the variables mentioned above. The second category also included those ISO certified firms that were not implementing Lean and Six Sigma. The category one includes 23 firms classified as SSS and category two includes remaining firms classified as NSSS.

6.2.2. Existence of quality department and problem solving team in SMEs

The questionnaire captured information on whether SMEs have any quality department, teams for problem solving and frequency of team meetings, training provisions in the company, and measures used for capturing voice of customers.

Seven out of sixteen small firms do not have a quality department in place as compared to six out of forty-eight medium-sized firms, as shown in figure 6.3.

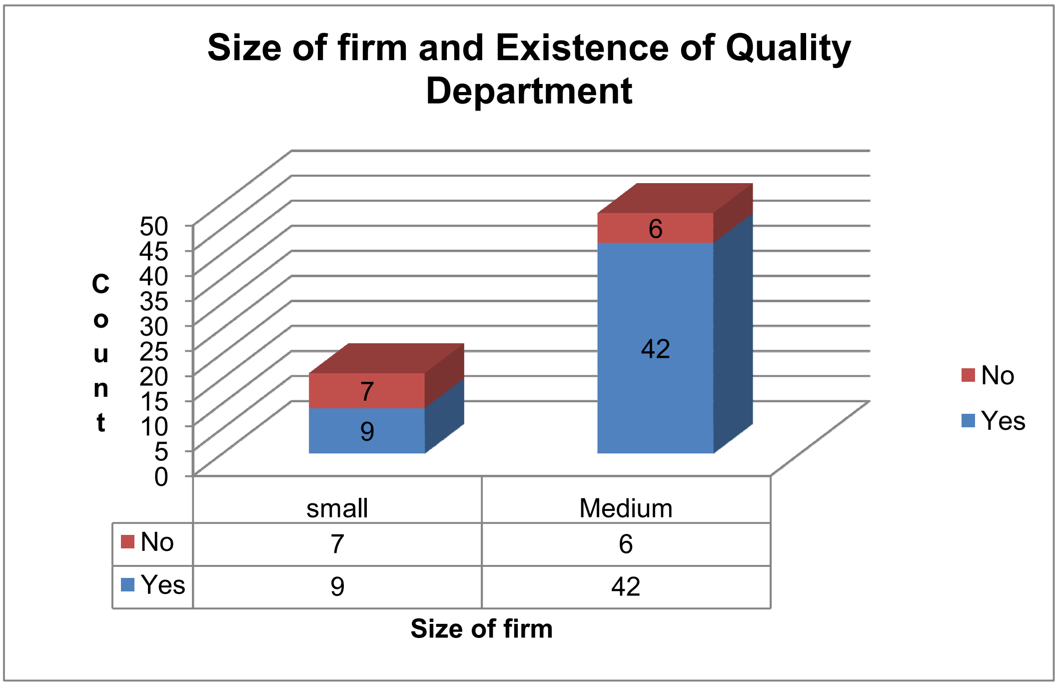

Figure 6.3: Existence of quality department within SMEs

In small firms, the employees are multi-skilled and capable enough to carry two to three responsibilities at the same time. Other reason may be that production engineer or the operations manager is delegated the responsibility of quality department. As the firm grows into medium-size, the structure becomes more formal and delegation of responsibilities is more structured.

To establish the statistical relationship between type (independent or part of MNC) / size of firms (small or medium) and existence of quality department, Chi-Square significance test for degree of association between two variables was conducted. The hypothesis proposed for testing the association is presented below

H_0: There is no association between size / type and existence of quality department (Null hypothesis)

H_1: There is significant association between size / type and existence of quality department (Alternate hypothesis)

There was no association between type of firm and existence of quality department, i.e. whether a firm is an independent entity or a part of MNC, it has no association with the existence of quality department, as the p-value (0.082) is greater than 0.05 and thus rejecting the null hypothesis.

Table 6.4: Chi-Square test between size / type of firm and existence of quality department

	Value	df	Asymp. Sig. (2-sided)*
Pearson Chi-Square (Size of firm)	7.240	1	.007
Pearson Chi-Square (Type of firm)	4.994	2	.082

**Test conducted at 5% significance level*

In the second case, it was statistically proved that significant association exist between size of firm (small and medium-sized) and existence of quality department as p-value (0.007) was less than 0.05. In this case, alternate hypothesis was accepted, indicating small firms were less likely to have quality department as compared to middle-sized firm. This was further verified from the data presented in figure 6.3. 44% of the small firms had no quality department in place as compared to 13% of the medium-sized firms. When asked about existence of team for problem solving in the firm, similar result was obtained from small and medium-sized category, i.e. 31% of the firms in both categories do not have team formed for problem solving activities in the firm, as shown in figure 6.4.

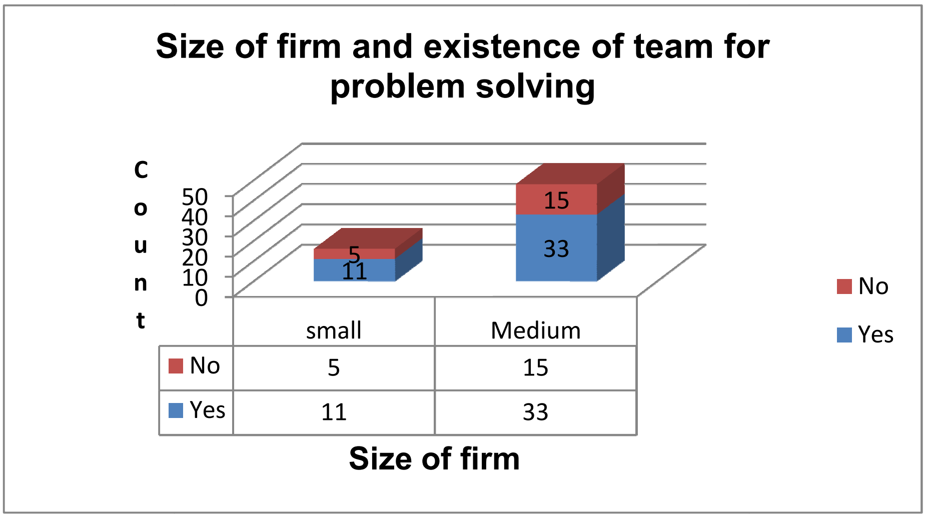

Figure 6.4: Existence of problem solving teams in SMEs

Medium-sized firms held more team review meetings during a week as compared to small firms, refer to table 6.5, for resolving mundane problems or complex problems in the organization. However, in many cases meetings were held in small and medium-sized firms on a weekly basis or only when problem occurred. The team meetings for problem solving in medium-sized firms were more often and frequent than small firms.

Table 6.5: Team review meetings in participating firms

Team meeting(s)	**No. of Employees**	
	10-49	50-249
	%	%
few times/week	9%	24%
once a week	26%	23%
once/2 week	19%	11%
only when problem occurs	27%	29%
Others	19%	13%

6.2.3. Methods of knowledge transfer to employees

The detail of approaches existing within SMEs for training and knowledge transfer (KT) to their staff was presented in table 6.6. Majority of the SMEs provided in-house training to their employees rather than seeking external help of consultants. They also resided on internet, books / research articles, and self-education as a medium to train their employees. Only 17.2% firms participated in conferences/workshops/seminars and considered it as a medium of networking and updating their knowledge on the latest business strategies. A further analysis revealed that SSS prefer to take external consultants help or attend conferences and workshops for enhancing their knowledge compared to employees in NSSS.

Table 6.6: Knowledge Transfer Mechanism in SSS and NSSS

Knowledge Transfer (KT) Mechanism	**All sample SMEs**	**Six Sigma SMEs**	**Non-Six Sigma SMEs**	**Pearson Chi-Square Sig. Test***
	% usage of measures			
In-house Training	93.8%	95.7%	92.7%	0.101
Conferences	17.2%	26.1%	12.2%	*0.046***
External Consultants	31.3%	43.5%	24.4%	*0.033***
Internet	14.1%	13.0%	14.6%	0.110
Self-Education	18.8%	17.4%	19.5%	0.105

Book/research articles	9.4%	13.0%	7.3%	0.543
Other methods	9.4%	4.3%	12.2%	0.687

** PEARSON CHI-SQUARE TEST AT 5% SIGNIFICANCE LEVEL*
*** Variables significant at 5% significance level*

However, the main source of knowledge sharing and transfer in SSS and NSSS was through in-house training of employees. The findings were statistically validated by conducting Chi-Square test of degree of association between the type of quality initiatives and mechanism used for KT. The finding from the Chi-Square test clearly shows that attending conferences and seeking external consultants help was more prevalent in SSS compared to NSSS. There was no critical differences in other mechanisms of KT between two groups as the Pearson Chi-Square significance value was greater than 0.05. The aforementioned variables were further tested against two control variables, i.e. type and size of firm to test the degree of association between KT mechanism and control variables (refer to table 6.7).

Table 6.7: KT mechanism against type/size of firm

Knowledge Transfer (KT) Mechanism	**Type of Firm**				**Pearson Chi-Square Sig. Test***
	Local Firm		*Part of MNC*		
	Count	%	Count	%	
KT by training	45	76.3%	14	23.7%	0.520
KT by Conferences	6	54.5%	5	45.5%	0.109
KT by Consultants	15	75.0%	5	25.0%	0.743
KT by Internet	8	88.9%	1	11.1%	0.629
KT by Self-education	9	75.0%	3	25.0%	0.860
KT by Book/research articles	5	83.3%	1	16.7%	0.894
Knowledge Transfer (KT) Mechanism	**Size of Firm**				**Pearson Chi-Square Sig. Test***
	10-49		*50-249*		
	Count	%	Count	%	
KT by training	15	25.00%	45	75.00%	0.998
KT by Conferences	3	27.27%	8	72.73%	0.848
KT by Consultants	5	25.00%	15	75.00%	0.991
KT by Internet	3	33.33%	6	66.67%	0.553
KT by Self-education	3	25.00%	9	75.00%	0.997
KT by Book/research articles	1	16.67%	5	83.33%	0.620

** PEARSON CHI-SQUARE TEST AT 5% SIGNIFICANCE LEVEL*

There was no degree of association between type/size of firm and KT mechanism as Pearson Chi-Square significance value was greater than 0.05 for the KT variables.

Irrespective of type of quality initiatives / type of firm / size of firm, no significant differences was observed in the KT mechanism of the participating SMEs.

6.2.4. Customer focused measures in the firm

The respondents were asked to state criteria used to capture and measure the voice of customers (VOC). Respondents were given options of multiple answers in order to capture all the measures existing / used by SMEs to understand the customer raised issues and problems. The results of the analysis were shown is figure 6.5. Majority of the firms (89.1%) used customer complaints as a medium to understand the critical business issues followed by criteria such as delivery time (60.9%) and customer survey (59.4%). A comparative analysis of SSS against NSSS was performed across the listed factors, as presented in the table 6.8. Similar results were reported for SSS and NSSS with respect to capturing VOC. Percentage of SSS using delivery time as a measure differs significantly from NSSS (82.6% for SSS against 48.8% for NSSS).

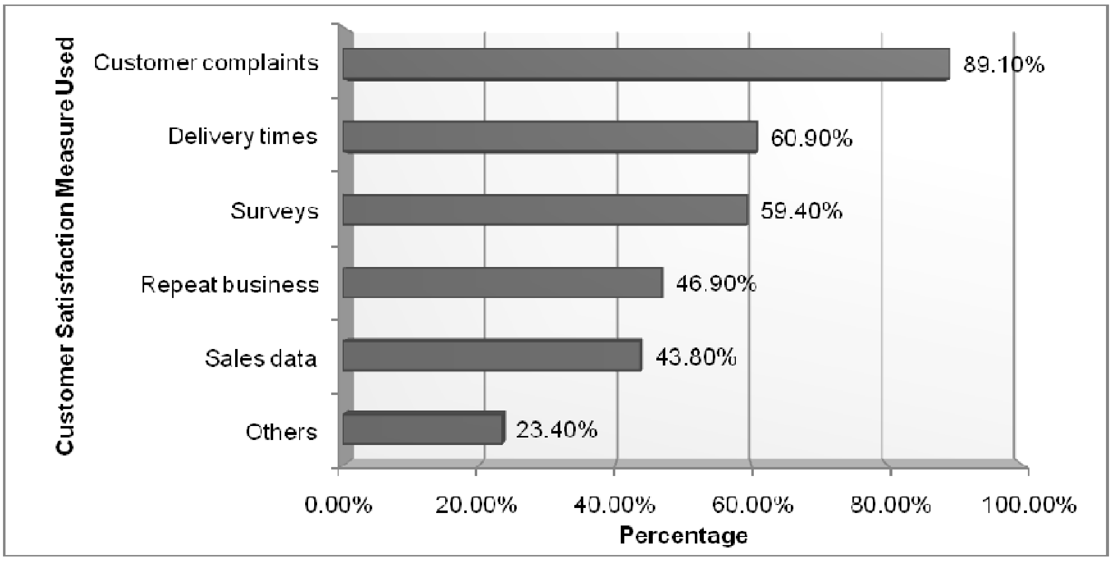

Figure 6.5: Measures used to capture voice of customers

The Pearson Chi-Square significance value for delivery time was less than 0.05, which proves the hypothesis that delivery time was more prevalent in SSS than NSSS to capture VOC. The respondents were also asked to cite the three most important criteria that helped the firm to win customer loyalty.

Table 6.8: Customer focused measure in SSS and NSSS

Factors for Comparison	**Six Sigma SMEs**	**Non-Six Sigma SMEs***	**All sample SMEs**	**Pearson Chi-Square Sig. Test***
Measures to capture Voice of customer	% usage of measures			
Surveys	69.9%	53.7%	89.1%	0.223
Delivery Time	82.6%	48.8%	60.9%	0.035**
Customer Complaints	91.3%	87.8%	59.4%	0.991
Sales Data	43.5%	43.9%	46.9%	0.998
Repeat Business	43.5%	48.8%	43.8%	0.897
Others	34.8%	17.1%	23.4%	0.543
Criteria that helped company to win customer loyalty	% usage of measures			
Manufacturing Quality	90.9%	80.5%	84.1%	0.785
Product Reliability	68.2%	68.3%	68.3%	0.998
Delivery Lead Time	27.3%	31.7%	30.2%	0.981
On-Time Delivery	72.7%	43.9%	54.0%	*0. 045***
Wide product Range	13.6%	26.8%	22.2%	0.124
Price	18.2%	41.5%	33.3%	0.435
Others	13.6%	4.9%	7.9%	0.657

** PEARSON CHI-SQUARE TEST AT 5% SIGNIFICANCE LEVEL*
*** Variables significant at 5% significance level*

This question was designed to gauge the importance that the company gives to its customers and try to win their loyalty. The criteria used to win orders were divided into seven categories and the results from the analysis showed that *manufacturing quality, product reliability, and on-time delivery* of the final product were the three most important criteria that SMEs focuses on to win customer orders. It was interesting to observe that price of the product was given low importance as compared to manufacturing quality and product reliability. On-time delivery was identified as the significant variable from the Chi-Square test, refer to table 6.8, that was frequently used measure in SSS as compared to its counterpart, i.e. NSSS. The Pearson Chi-Square test revealed no association between the type/size of firms and VOC measures / criteria used to win customer loyalty.

6.2.5. Factors defining the strategic objective (s) of the firm

The respondents were asked to shortlist three largest factors out of seven alternatives available, which define the company strategic objective (s). The alternatives available were profitability, flexibility, quality, market share, innovation, cost and other category. The results from the analysis were presented in figure 6.6 below.

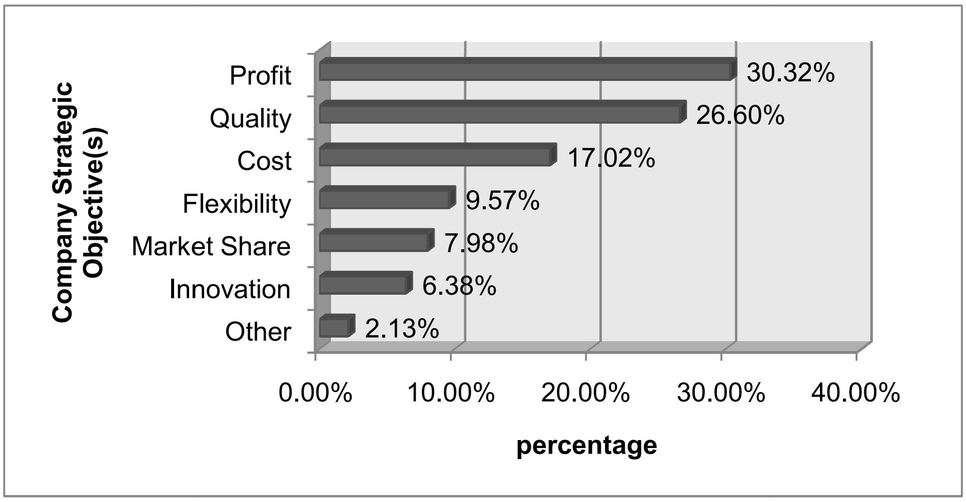

Figure 6.6: Factors defining the strategic objective (s) of the firm

The three most important factors cited by the sample firms that helped them in deciding their strategic objectives were profitability, quality, and cost. Analysis of the strategic objectives with respect to the type of quality initiatives (SSS and NSSS) and size/ type of firm revealed that profit, quality, and cost was considered as the top three objectives irrespective of the type/size of the firm or type of QI implemented in SMEs. Market share and innovation was not considered as important by the senior management team to link with strategic business goals. The reason may be attributed to the SMEs preference of maintaining status–quo and having no desire to grow (as indicated from the literature review on small business growth in Chapter 2). It is imperative for the firms to be innovative in order to sustain the competition and their existence in the global market.

6.2.6. Reasons for not implementing Six Sigma in SMEs

Large organization have been implanting and reaping the benefits of Six Sigma in the last two decades. However, its application in SMEs is still less evident as cited in the literature. It was important to understand the perception of Six Sigma and factors hindering its implementation from the SMEs perspective. Firms were asked to state the reasons for not implementing Six Sigma as an initiative to drive continuous improvement effort within their firms. As depicted in the table 6.9, majority of the firms were discouraged to implement Six Sigma due to lack of knowledge of the system to kick off the initiative (29.27% of the total firms not implementing Lean or Six Sigma). This was followed by other reasons such as lack of resources, not sure if relevant, never heard, and cost issues.

Table 6.9: Reasons for not implementing Six Sigma in SMEs

Reasons for not implementing Six Sigma	**%**
Lack of Knowledge of system to kick off	29.27
Not sure if relevant	21.95
Availability of Resources	19.51
Never heard	17.07
Cost issue	17.07
Other competing initiatives	14.63
ISO is accepted and necessary	12.20
Leadership Desire	12.20
Suitable for large company	7.32
Bureaucratic	4.88

6.3. Critical Success Factors (CSFs) and Impediment study

6.3.1. Critical Success Factors study

The respondents were asked to rate the importance of CSFs within the company, with 1 corresponding to “not important at all” and 5 as “very important”. In order to find the gap between the importance of CSFs and its actual practice in-company, a similar rating scale (1 represents “very poor practice” and 5 corresponds to “very good practice”) was used to measure the extent of implementation of CSFs within firms. From table 6.10, it was found that leadership and management commitment was considered the most important factor and vision & plan statement and IT & innovation received the lowest mean value of importance. Most of the variables had a mean importance equal to or greater than 4.

Table 6.2: Gap analysis of CSFs of quality practices in SMEs

Critical Success Factors	Importance	Practice	GAP	Sig.*
Leadership & Mgmt commitment	4.73	3.97	0.76	0.000
Communication	4.70	3.59	1.11	0.000
Link QI^ to employee	4.44	3.36	1.08	0.000
Cultural change	4.38	3.19	1.19	0.000
Education & training	4.27	3.27	1.00	0.000
Link QI to customer	4.22	3.36	0.86	0.000
Project selection	4.19	3.22	0.97	0.000
Link QI to Business	4.14	3.28	0.86	0.000
Link QI to supplier	4.14	2.97	1.17	0.000
Project mgmt skill	4.03	3.17	0.86	0.000
Org infrastructure	3.97	3.57	0.40	0.003
Vision & Plan	3.97	3.46	0.51	0.003
IT & innovation	3.83	3.17	0.66	0.002

^ QI stands for Quality Initiative

** Test performed at 5% sig. level*

On the contrary, in practice within the company, each factor was found to be less applied with mean practice value less than 4 for all factors. *Spearman Correlation significance test* was performed (at 5% significance level) to identify whether the *mean* value for importance and actual practice of CSFs were statistically different from each other. The result of the analysis showed that each factor was statistically significant in terms of application and perceived importance of CSFs within SMEs. It may be inferred from table 6.10 that even though the company had the quality systems or quality initiatives in place, still huge gap existed in between importance and practice of those CSFs, which may have an impact on the organizational performance.

The CSFs were compared against the size (type) of firm to understand the variation in result with respect to the control factors. Table 6.11 includes the information on the mean score of CSFs (importance and practice) against the size of firms. The score for average importance and practice of each factor with respect to the size of firm yielded similar result as observed in table 6.10. The Spearman Correlation test for the size of firms revealed no significant differences between the two groups and the aforementioned CSFs. The findings were exactly similar for other control variable, i.e.

the type of firm. Thus, it was statistically proved that size and type of firm had no degree of association with CSFs variable used in this study.

Table 6.3: CSFs study against size of the firm

	10-49	50-249	Sig. Test*	10-49	50-249	Sig. Test*
Critical Success Factors	**Importance**	**Importance**		**Practice**	**Practice**	
Leadership & Mgmt commitment	4.64	4.77	0.446	4.18	3.97	0.519
Communication	4.91	4.65	0.136	3.45	3.68	0.801
Link QI to employee	4.64	4.43	0.449	3.27	3.50	0.477
Cultural change	4.55	4.39	0.312	3.27	3.26	0.837
Education & training	4.55	4.26	0.343	3.18	3.42	0.504
Link QI to customer	4.36	4.27	0.752	3.64	3.30	0.384
Project selection	4.18	4.20	0.950	3.09	3.33	0.656
Link QI to Business	4.55	4.03	0.135	3.64	3. 17	0.314
Link QI to supplier	4.27	3.97	0.115	3.45	2.73	0.151
Project mgmt skill	4.18	4.03	0.555	3.00	3.33	0.282
Org infrastructure	4.09	3.94	0.495	3.82	3.45	0.389
Vision & Plan	4.09	3.97	0.353	3.45	3.55	0.769
IT & innovation	3.73	3.70	0.716	3.00	3.23	0.457

** SPEARMAN CORRELATION TEST AT 5% SIGNIFICANCE LEVEL*

The comparison of CSFs between SSS and NSSS, details provided in table 6.12, revealed that there was no significant difference in terms of importance of the CSFs in SSS and NSSS. SMEs implementing ISO and other quality initiatives perceived the importance of these CSFs in a similar way as firms implementing Lean and/or Six Sigma. The CSFs findings clearly indicated that irrespective of type of initiatives a SME was undertaking, *leadership and management commitment was the most important factor to make the initiative successful followed by communication, employee involvement, culture change, training and focus on voice of customers.* The top seven ranked CSFs were related to the softer side or the human side of implementation. The result indicated that it is the softer factors that make any QI implementation successful in organizations and thereafter the priority is given to the harder factors like project management and usage of tools and techniques of CI.

Table 6.4: Comparison of CSFs between SSS and NSSS

	Six Sigma SMEs	Non-Six Sigma SMEs	Sig. Test*
Critical Success Factors	**Importance**	**Importance**	
Leadership & Mgmt commitment	4.88	4.67	0.586
Communication	4.82	4.67	0. 485
Link QI to employee	4.44	4.43	0.998
Cultural change	4.41	4.37	0.991
Education & training	4.47	4.20	0.443
Link QI to customer	4.38	4.17	0.446
Project selection	4.25	4.23	0.997
Link QI to Business	4.06	4.10	0.991
Link QI to supplier	4.00	4.23	0.544
Project mgmt skill	4.00	4.10	0.787
Org infrastructure	3.71	3.97	0.633
Vision & Plan	3.94	3.83	0.885
IT & innovation	3.56	3.93	0.234

** SPEARMAN CORRELATION TEST AT 5% SIGNIFICANCE LEVEL*

6.3.2. Impeding factors in implementation of quality initiatives in SMEs

Companies were asked to identify the top five inhibiting factors that were considered as barrier to quality initiative implementation. The results of the analysis shows, refer to figure 6.7, that about 71.2% percent of the responding firms stated that lack of resources was one of the impeding factors to the successful introduction of a quality initiatives in UK SME. Lack of resources covered a large number of aspects including financial resources, human resources, time, etc. This was followed by lack of knowledge, poor training/coaching, internal resistance, poor employee participation, etc. Lack of resources is the most common impeding factors, as cited in the SMEs literature on CI initiatives that deters the progress of any change management program in SMEs. However, it was surprising that lack of top management commitment was excluded from the list of top five impeding factors.

All the aforementioned CSFs and impediments identified from survey response were further investigated in the second phase of study while conducting multiple case studies in ten manufacturing SMEs.

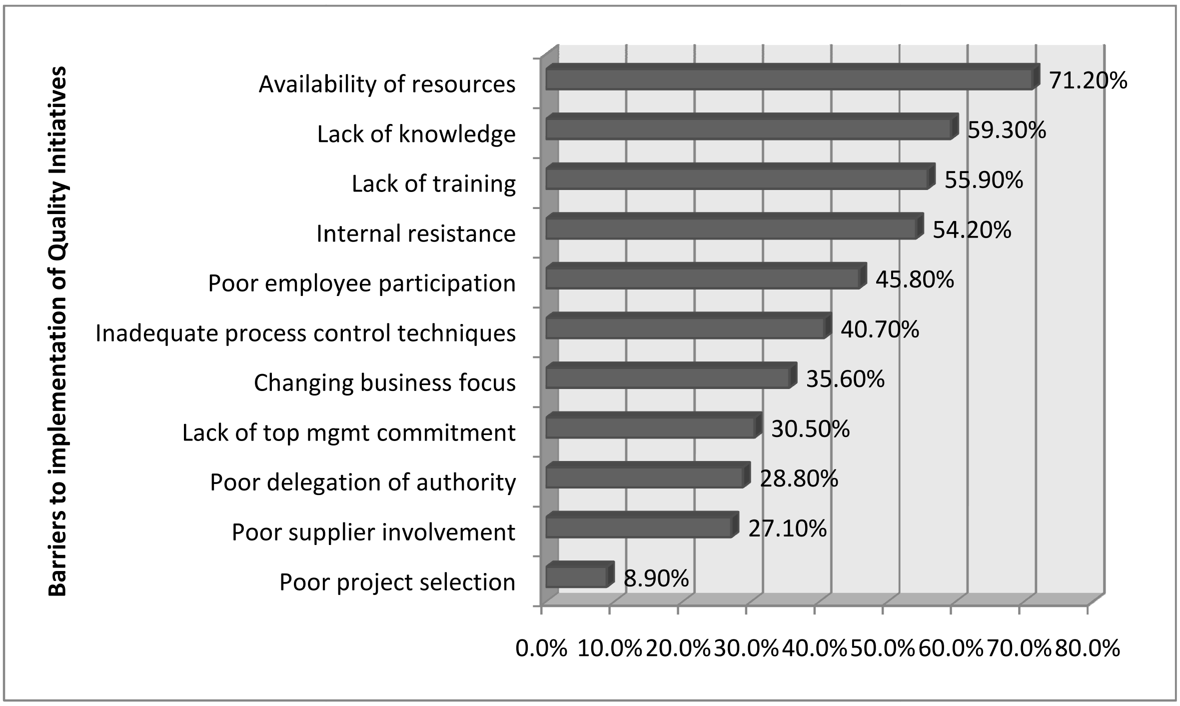

Figure 6.7: Barriers to implementation of Quality Initiatives in SMEs

6.4. Performance of SSS and NSSS: A comparison

The respondents were asked to rate the benefits realized through implementation of QI using a Likert scale of 1 to 5, where 1 = negative benefit, 3= some benefit and 5 = crucial. Table 6.13 and table 6.14 showed the degree of improvement realized on 1-5 scale after the implementation of QI. Score across each of the performance indicator reflects the improvement made by the SME after implementing the QI. A comparison of small firms and medium sized firms were conducted against the performance indicators to check the degree of association between the size of firm and performance indicators, as shown in table 6.13 below.

Table 6.5: Performance Indicators comparison against size of firms

Performance Measures	**No. of Employees**		**Sig. Test***	**All SMEs**
	10-49	**50-249**		
	Mean	Mean		Mean
Reduction in scrap rate	4.33	3.61	0.088	3.78
Reduction in cycle time	4.11	4.14	0.953	4.14
Reduction in delivery time	3.67	3.64	0.962	3.65
Increase in productivity	4.56	3.93	0.086	4.08
Reduction of cost	3.67	3.57	0.805	3.59

Increased profitability	3.56	3.64	0.834	3.62
Increased Sales	3.11	3.50	0.401	3.41
Reduction of customer complaints	4.00	3.64	0.414	3.73
Reduction of employee complaints	3.44	3.75	0.605	3.68

** SPEARMAN CORRELATION TEST AT 5% SIGNIFICANCE LEVEL*

The significance test revealed no differences in the performance of small firms as compared to middle-sized firms after the implementation of QI. Similar results were obtained when comparing the performance of independent local firms against firms being part of MNC. Spearman correlation test statistically identified no degree of association between size/type of firms against the aforementioned performance indicators. Irrespective of the type or size of firms, significant improvement was observed in cycle time and productivity after the implementation of QI, as stated in table 6.13. Table 6.14 summarizes the key benefits gained from the implementation of Six Sigma and is compared against the performance of NSSS with respect to variables mentioned in table 6.14.

Table 6.6: Impact of quality initiatives on the firm performance

Performance Measures	**SSS**		**NSSS**		**Sig.* value**
	Mean	Std. Dev.	Mean	Std. Dev.	
Reduction in scrap rate	3.52	.829	2.82	.872	0.000
Reduction in cycle time	3.38	.875	2.80	.940	0.003
Reduction in delivery time	3.24	.872	2.84	.926	0.002
Increase in productivity	3.79	.726	2.84	.746	0.000
Reduction of cost	3.50	.777	2.88	.752	0.000
Increased profitability	3.40	.770	2.35	.797	0.000
Increased Sales	3.50	.900	3.04	.889	0.003
Reduction of customer complaints	3.65	.950	3.07	.961	0.003
Reduction of employee complaints	3.27	1.072	3.00	1.087	0.024

** SPEARMAN CORRELATION TEST AT 5% SIGNIFICANCE LEVEL*

Testing the mean performance of SSS against NSSS revealed the significant differences in performance of NSSS compared to a firm implementing Six Sigma. Six Sigma firms were performing better on the operational metrics like reduction in scrap rate, cycle time, delivery time and increase in productivity. Even in the strategic measures of organizational performance, i.e. reduction in cost, increased profitability and increase sales, SSS out classes NSSS.

Performance of six firms implementing only Lean out of 23 (SMEs not implementing Six Sigma or ISO) were also recorded with respect to the variables mentioned in table and it was revealed that the mean performance of these firms were above ISO certified SMEs but below firms implementing Lean and Six Sigma, though not statistically significant. This analysis gives an indication that Lean firms implementing Six Sigma have realized more benefits compared to SMEs implementing Lean on its own.

The participating firms were also asked about their knowledge on cost of poor quality (COPQ) and factors they included to measure COPQ. Thirty four firms (53%) had no understanding of COPQ and other thirty firms (47%) indicated some understanding of COPQ. An open ended question was further asked to firms as what constitute COPQ or the factors they considered while measuring COPQ. Most of the SMEs had very limited knowledge of COPQ and included scrap and rework while measuring COPQ. There were minimal differences in the understanding of COPQ between SSS and NSSS. It can be said that COPQ is still an unexplored area in a SME environment based on the findings of the study.

6.5. Summary

It is a myth that Six Sigma works only in large companies. Six Sigma has evolved into a business strategy in many large organizations and its importance in SMEs is growing everyday, as depicted from the survey results. The novelty of this chapter lies in conducting a comparative study on the quality management practices of SSS and NSSS, drawing value lesson for the academics, consultants, researchers and practitioners of continuous improvement initiatives like Lean and Six Sigma. This is among very few studies that have identified the differences in quality management practices and performance between Six Sigma and non-Six Sigma firms.

Majority of the small firms as compared to middle-sized firms struggled to have a quality department in place. The reason may be attributed to its informal structure and resolving problem based on the individual gut feeling. SSS and NSSS resided on customers complaints as the primary method to capture voice of customers followed by using other important criteria such as customer survey and delivery time. However, SSS seek the help of external consultants more often for training their employees as compared to NSSS, where in-house training was the main source of knowledge transfer.

Profit, cost, and quality were rated as the three most important factors (independent of size/type of firm or type of quality initiatives implemented) that defined the strategic objectives of the firm. Three important measures used in the sample firms to win customer loyalty were identified as manufacturing quality, product reliability, and on-time delivery. The score of these three factors were also independent of the type/size of firms or type of quality initiatives implemented in firms. The common reasons cited for not implementing Six Sigma in the firms were similar to literature- lack of knowledge of system, never heard about Six Sigma, lack of availability of resources to implement Six Sigma, not sure if Six Sigma is relevant to their organizations, and cost issues.

Results of the survey revealed that factors critical to success of quality initiatives were equal in importance, irrespective of type of initiatives implemented by the firm. Strong Leadership and management commitment are required to make any change initiatives successful in the organization. It should also be linked to employees in terms of training, making resources available and establishing good communication with them. The score for operational and strategic performance metrics of SSS were higher than NSSS, giving an indication that Six Sigma is beneficial for all types of firm, irrespective of the size of the firm. This statement was further validated through conducting multiple case studies in SSS and comparing its performance with NSSS, the results of which were presented in the next chapter.

Considering the low response rate in the first phase of Doctoral research, it was decided to perform a multi-level multiple exploratory case studies within SSS and NSSS identified from the survey response. The case-study research facilitated in performing an in-depth cross case analysis and identified significant differences existing in the quality management practices of SSS and NSSS.

Chapter 7
Case Study Analysis

7.0. Introduction

The findings from ten case study firms, 3 practitioner interviews, and responses from 30 delegates attending the 3rd International Conference on Six Sigma (15th -16th December, 2008; Edinburgh) were presented in this chapter. The primary unit of analysis was two clusters, i.e. Six Sigma SMEs and Non-Six Sigma SMEs. The secondary unit of analysis included 5 case study SMEs within the Six Sigma cluster and another 5 SMEs within the non-Six Sigma cluster. *Twenty-four semi-structured interviews were conducted in the ten case study firms*. The a*uthor used a three step technique (data reduction; data display; data analysis and drawing conclusion) proposed by Miles and Huberman (1994) and the two step process proposed by Eisenhardt (1989), which is simple, comprehensive, and most widely cited, for analyzing the qualitative data*.

This chapter is divided into the following sections: the first section discusses findings from Six Sigma firms; the second section includes findings from Non-Six Sigma firms; findings from practitioner interviews were presented in the third section; the next section included discussion on differences in SMEs and large organizations and the Six Sigma Readiness Index based on comments from the respondents; the last section briefly summarizes the key findings.

7.1. Findings from Six Sigma firms

7.1.1. Demographic Details of Six Sigma SMEs

Company A was established in 1984, specializing in design and manufacture of PC data communications hardware. It employed 36 people with an annual turnover of £3.4 million in 2007. The entire design and manufacturing was controlled at one facility, ensuring complete control over its processes to be proactive to customer demands. Some of its major customers included organizations ranging from banking to government agencies to defence equipment manufacturers to name a few. The commitment of the management team to devote 30% of the expenditure in research and development has contributed to the development of a world-class manufacturing facility on-site. *A* (Company A is denoted as *A* from this section onward) had won several awards in the last two decades including the 'European Manufacturer of the Year' and 'Microsoft Tech-Ed' awards due to its success in maintaining a growing manufacturing capability that embraces Lean and Six Sigma.

Company B was formed in 2002 from the merger of two parent companies (each of the parent company employed less than 50 people) in England. Presently, there were 106 employees generating an annual turnover of £5 million. *B* (Company B is denoted as *B* from this section onward) provided precision engineered metallic sealing solutions, from design and prototype to full volume production, and services to the highest standards. *B* specializes in the design and manufacture of high temperature metal seals, gaskets, CNC machined components and complementary products for the aerospace, automotive and industrial sectors.

Company C is part of multi-national corporation (MNC), with it's headquarter in the USA, which has been a global leader in blood processing technology for more than 30 years. Company C (Company C is denoted as *C* from this section onward) was established in 1994 in Scotland with 80 employees and the figure had tripled in 2008 to 240 employees. Some of *C'*s key products included surgical auto-transfusion devices, surgical field blood suction systems, filter bag, and blood and patient warming systems. *C* gross profit and operating income had grown since 2003 and had shown positive signs of growth in the fiscal year 2009/2010. Core competency of the parent company lies in manufacturing process, sales/service, and market innovation. The parent company vision was to become global leader in blood management solutions for their customers.

Company D, established in 1974 in Scotland, is a provider of flow measurement equipment for the oil and gas industry and was acquired by a MNC in 2000 to support its penetration into the gas flow measurement market. The parent company was at the forefront of measurement technology development, for more than 70 years, for the oil and gas industry. It relied on precision manufacturing to ensure that specifications were met or exceeded to offer the best quality product in the marketplace. *D* (Company D is denoted as *D* from this section onward) currently has 105 employees with an annual turnover of £20 million. *D* was involved in the manufacturing of a low-volume, high-mix product type that includes components such as meters, valves, flow-control instruments, instrumentation and read-out equipment and process management components.

Company E started with 11 employees in the mid 1990s before being taken over by large Swedish engineering company in 2002. The parent company is the world leader in handheld vibration data collection technology for condition monitoring, supplying the major OEM's in this market. *E* (Company E is denoted as *E* from this section onward) focused on the electronics part of the business, where they monitor the wear and vibration of the bearings, seals and other parts of the parent company. The core business of *E* was to manufacture a customized handheld rugged computer that measured sound, noise and vibration of parts in machine to estimate their failure time. The annual turnover of *E* was in the range of £1-£5 million (the company was not happy to reveal the exact data of annual turnover). *E* currently has a headcount of 35 employees.

Other demographic details of the companies are provided in table 7.1. The five case study firms are involved in different manufacturing activities ranging from electronics & semi-conductor to mechanical and pharmaceutical industry. *A* and *B* are local independent firms, whereas *C, D*, and *E* were a part of MNC.

Table7.1 Company demographic details

Company	Manufacturing Activity	Company Type	Annual Sales Turnover	Location	No. of employees
A	Electronics & Semi-conductor	Independent	£3.4 m	England	36
B	Mechanical	Independent	£5 m	England	106
C	Pharmaceuticals	Part of MNC	-	Scotland	240
D	Mechanical	Part of MNC	£20 m	Scotland	105
E	Electronics	Part of MNC	£1-£5 m	Scotland	35

7.1.2. Quality Management Practices in SMEs

7.1.2.1. History of Quality Initiatives

A started with accreditation of BS 5750 in 1994 followed by ISO 9001:2000 certification in 2001. Further extending its continuous improvement (CI) journey, the company started Lean implementation in 2001, IIP certification in 2002, and embarked on the Six Sigma journey in 2003. The company *failed to implement Lean successfully* in its first attempt in 1998 *due to poor communication and no involvement of employees at the shop-floor level*. The lessons learnt from this mistake helped the company to successfully implement Lean in 2001 by introducing it at shop-floor level. All the employees in the company attended a one day workshop on basics of Lean and its impact on business processes improvement. Once the employees realized the benefits from Lean implementation and started believing in the principle of continuous improvement, the management decided to embark on Six Sigma to tackle the variation problems existing in their business processes. Suppliers were selected based on the criteria of ISO 9000 and their quality of raw materials was investigated on a continuous basis.

Before *B* was formed by the merger of two parent companies, it achieved AS 9100 certification required for the aerospace industry and TS 16949 certification for the automotive industry. After the merger, the firm has acquired ISO 9001:2000 certification in 2003 followed by Lean implementation in 2005. In early 2007, Six Sigma principles were embraced after streamlining the business functions using the Lean concept. At the time of interview, the company had already started applying Lean and Six Sigma principles in the administrative and finance processes. *B* implemented the concept of the *theory of constraints (TOC) and TQM* in the past but *failed to succeed* due to *lack of training for shop-floor employees, poor top-down communication, and involvement of middle managers in day to day jobs* apart from TQM/TOC implementation responsibility (for which they didn't have time to implement and execute projects). Similar to *A*, ISO 9000 was the prerequisite to become the supplier of *B*.

C, being part of a successful MNC, was very cash rich and had a very healthy balance sheet. The parent company had witnessed significant growth in its USA, European, Asian and African markets by consistently investing resources for its research and development (R & D), and improving the quality of its products by implementation of initiatives like Lean and Six Sigma across all its subsidiaries including C. *C* went for ISO 9000 certification in 1994 and ISO13485 for medical devices in 1997. Lean was rolled out at company-wide level in 2000, involving everybody in the company followed by Six Sigma implementation in 2003. '*C'* implemented the *Hoshin Kanri* approach in 1996, but *failed to gain management commitment* and that initiative was forgotten in a few months time after being launched. *Lean* was first implemented in 1998 but was *not successful* as *shop-floor employees were not involved*. Being part of a MNC, *C* does not have authority to conduct R & D exercises at their site and any simple changes in product/process need to be approved by the parent company. They have the authority for any operational decisions related to yield, productivity, streamlining business processes, and taking corrective actions.

Senior management in *D* went for BS5750 accreditation through the British Standard Institute (BSI) in 1991 due to the oil and gas industry driving the demand for suppliers to be BS5750 certified followed by ISO 9000 certification in 1995. *D* had suggestion boxes for improvement, where people could put their ideas in the box and if it was considered a good idea it would be discussed in the management review meeting. The next major change was ISO 9001: 2000 that coincided with the parent company buying *D.* However after acquisition by a MNC, the quality profile of the organization was raised significantly due to commitment from the new CEO, who was passionate about customer focus and the quality philosophy proposed by Deming. *D* was to become a *System Thinking* company using their newly developed *six step process* for continual improvement as presented in figure 7.1, in striving to improve business performance. Continuous improvement process (CIP) was the six step process used within *D* for process improvement. *D* had vision and mission statement established strategies in place that were governed by the parent company. Any training conducted at *D's* site such as product training, educational, health & safety training, to name a few, the information was sent to the parent company. The parent company being proponent of Lean, placed many of their technically proficient staff in Lean at *D's* site in 2004 for training their employees. The Managing Director (MD) of *D* was inclined towards Lean and getting the support from the Director of the parent company hired a Lean Champion for Lean deployment across the organization. Six Sigma was slowly rolled out in 2006 after gaining commitment at all levels in the organization.

However, *both the initiatives became fragmented* in the organization after the *Lean Champion moved to a different company* and there were no other employees confident enough to lead the change from the front. Again, there were changes in management structure at the corporate level in 2007. The p*arent company* was now more *focused on financial measures* and thus pressure was felt by *D* to *increase productivity by compromising quality* of its product, leading to the *failure of initiatives* such as Lean and Six Sigma.

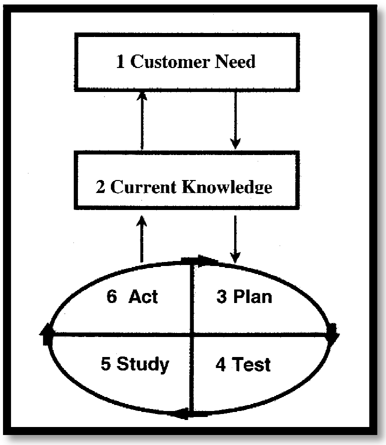

Figure 7.1: *D's* six-step process for Continuous Improvement

D does not have any quality program for their suppliers and follow traditional inspection methods to control raw material/ product quality. They deal with customer complaints using a software package provided by the parent company called Enterprise Quality Management System (EQMS), which was very costly to use. The software was customized for *D* but was not very successful. *D* now conducts customer surveys to listen to the voice of customers.

E secured ISO 9000 certification in 1998 and ISO 13485 certification for use in medical applications in 2004. ISO 13485 ensures that all parts used meet the specification for medical equipment. After being takeover by Swedish MNC, *E* got involved in the development of the Six Sigma program in 2006 due to the popularity and success of program in the parent company. The MD of *E* adhering to the advice of the parent company and realizing the efficacy of the Six Sigma program, promoted the initiative in the company. Due to the type of product manufactured (low volume-high mix), *E* had struggled to identify an improvement project applying Six Sigma methodology. *E* was considering going down the route of Design for Six Sigma (DFSS) that may help in getting the design right first time. Thus, at the company site, employees were more involved in process improvement teams for problem solving. During the pre-acquisition time, several quality problems in the company were not resolved due to lack of systematic procedures and data collection methods in place. A minimum criterion for supplier selection in *E* was to have ISO 9000 certification to secure a contract with the company. The company representatives often used to travel once or twice in a year to the USA to understand the VOC and then design the customized product. Interviewees were not aware of any quality initiatives that failed to demonstrate benefits for the company. A brief summary of quality initiatives in the five participating firms and reasons for the failure of quality initiatives in the sample firms were presented in table 7.2 and table 7.3 respectively.

Table 7.2: History of quality initiatives in case study companies

	A	B	C	D	E
History of quality program (QP) or certification achieved and the corresponding year	BS 5750 (1994) ISO 9001:2000 (2001) Lean (2001) Investors in People [IIP] (2002) Six Sigma (2003)	AS 9100 (1992) TS16949 (1994) TQM (1997) TOC (2001) ISO 9001: 2000 (2003) Lean (2005) Six Sigma (2007)	ISO 9000 (1994) ISO13485 (1997) Hoshin Kanri (1996) Lean (2000) Six Sigma (2003)	BS5750 (1991) ISO 9000 (1995) ISO 9001:2000 (2001) CIP (2002) Lean (2004) EQMS (2005) Six Sigma (2006)	ISO 9000 (1998) ISO13485 (2004) Six Sigma (2006)
Existing QP	Six Sigma; Lean	Six Sigma; Lean	Six Sigma; Lean	Six Sigma; Lean but struggling to realize benefit from it.	Six Sigma

Table 7.3: Reasons for failure of quality initiatives in case study companies

	A	B	C	D	E
Failed Initiative(s) & reasons for failure	*Lean (1998)* -Poor top-down communication - No shop-floor employees involvement - lack of training at shop-floor level	*TQM (1997), TOC (2001)* - Minimal training for all employees - Poor top-down communication - Lack of understanding of TOC /TQM - Middle managers pulled into daily work apart from conducting TQM projects	*Hoshin Kanri (1996)* -Failed to get top management commitment *Lean (1998)* - No shop-floor employee involvement	*Lean (2004), Six Sigma (2006)* -Lean champion moved to other company -Struggled to find a leader to lead the change -Change in management structure; new management focused only on financial benefits	NA

Interviewees were asked whether they followed a structure/ skeleton or framework to embark on the Six Sigma journey. None of the participating firms adhered to a framework for Six Sigma implementation. It was rather a haphazard approach taken by firms as a result of some funding secured (in the case of *A*), or support from OEMs (in the case of *B*), or driven by the parent firms (in the case of *C, D, and E*). The common steps followed in firms were communication from the top management on the need for Six Sigma, training few selected employees as Black Belts (BBs) and Green Belts (GBs), and executing a Six Sigma project in a pilot area. The benefits generated from the project were shared with the rest of the organization to break down any resistance for change existing in the organization and raise the awareness of the efficacy of program. *Interviewees strongly accentuated the need to develop a customized framework tailored to the needs of SMEs for successful implementation of Six Sigma. A structured and planned approach to implementation would facilitate long-term sustainability of learning and benefits realised from Six Sigma.* Firms commented on the need for a Six Sigma framework that takes into account the resource constraints issue faced by the majority of SMEs as significant initial investment is required to develop an organizational infrastructure for Six Sigma implementation.

7.1.2.2. ISO 9000 as a foundation to embark on Six Sigma

The results of the survey conducted in the first phase of this doctoral work revealed that out of 49 certified ISO firms, 17 firms have implemented Lean and 10 of the 17 Lean firms have gone down the route of Six Sigma. This finding implies that *ISO may be the foundation or building block before embracing Lean and Six Sigma*. This was tested by conducting interviews at senior and middle management level in the case study companies.

From *A*'s perspective, ISO 9000 is one of the foundational principles to get started with other business improvement initiatives. It does not guarantee product quality but helps in standardizing the process and following it through. The MD of *A* viewed ISO 9000 as "*the way of retaining and winning business. If you adopt a standard, it puts some structure in your company, which you can make work for you, and align it to your goal. We were better organized as to how we stored component. We had a more* *formal production line, everything labelled and defined (defined assembly process, inspection process, test process). I learnt that these standards are great enablers*".

Other senior and middle management executives opined that ISO helped the company in establishing the structure, implementing procedures and worked as a foundation to get started with Lean and Six Sigma. Similar findings were reported during the interviews with executives in *B, C, D*, and *E*. The new standard ISO 9001:2000, as believed by *A, B, and D* eliminates the bureaucracy with more focus on a proactive approach to data gathering and making continuous improvement. The interviewees in *A, B, C and D* strongly accentuated the point of having standardized procedures in place to understand processes and measure the process performance.

However, it is very important to train your employees on how to follow the procedures and adhere or make amendments to it according to the needs of the customer/market. The Quality Manager in *E* put stress on employee training and good design to make effective use of such accreditation. He further stated that *"ISO 9001 accreditation is effective for keeping people working to procedures; it is good for making people aware that there are procedures for how they do their job, procedures for how things should happen. But at the end of the day, if the design is poor or people are not trained, no use of such system".*

If the procedures are not formalized, employees do the same things in different ways, creating confusion and chaos in the organization. It is almost impossible to implement Lean or any kind of strategic improvement initiatives without having established processes and procedures in place. Supporting the above statement, the Operations Director of *C* stated that *"ISO certification is the way of doing business. We need to standardize procedure through ISO. The output from ISO made implementation of Lean easier than it would have been if we had not had ISO certification. I think that it makes sense to do ISO first followed by Lean and Six Sigma".*

It also depends on the maturity and existence of the firm: if it is a new business with 10-20 employees, ISO may help to establish the procedures. After documenting the procedures, the company is in a position to define its processes, understand the input/output, and start measuring its processes by collecting data. This is the time when the company is ready to embark on Six Sigma.

It was also accentuated in company *A, B, C* and *E* that Lean is better for the first round of improvement attacking the low hanging fruit to eliminate waste from the organization. It is easier to convince management and shop-floor employees to embrace Lean because the benefits are visible and quicker compared to Six Sigma. Some of the basic Lean tools like 5S give a feeling of empowerment and process ownership to shop-floor individuals as they can see the immediate benefits of standard house-keeping practice. Once the initiative has gained the appreciation of top management as well as shop floor employees, it is easier to implement Six Sigma to minimize any variations existing in the process.

The motivation for certification should not only be driven by demand from customers or markets but supported internally by the management team to have established standard procedures and mapped processes. If it is sought for a window dressing exercise, employees will find the initiative bureaucratic and a waste of their time. Similar opinion was observed while interviewing the Quality Manager of *D*- *"But the employees looked at it as bureaucratic and time consuming. However it all boils down to good leadership. It made people comfortable by establishing the procedure. But it hinders innovation and creativity as you adhere to the procedure. It is not a bad thing for the company. ISO 9000 certification was easier to achieve, however we forgot everything once we got certification".*

The aforementioned discussion supports the finding of the survey and the proposition that ISO may be the foundation for implementing Six Sigma. No company should consider ISO as their destination to the quality improvement journey. The focus should be on continuous improvement to sustain its performance in the global market. Lean may be used in the first round of improvement to eliminate the waste followed by Six Sigma applications to reduce the variation from the processes. However, to generalize the findings more case studies should be conducted with SMEs implementing Lean and Six Sigma.

7.1.2.3. Motivation to implement Quality Initiative(s)

Table 7.4 provided information on the motivation to implement CI initiatives such as Lean and Six Sigma in the case study companies. In both *A* and *B*, the implementation of initiatives such as Lean and Six Sigma were supported by the

Managing Directors (MD) of the companies. The MD in both firms communicated the need by addressing the entire organization about the competitive advantages provided by Lean and Six Sigma business strategies. The MDs were committed to keep the business sustainable on a long-term basis, resulting in the implementation of CI initiatives and allocating resources to drive improvements in quality, performance, and customer satisfaction. Other reasons cited by *A* and *B* to embark on the Lean and Six Sigma journey were presented in table 7.4. The management team in *A* took the view that *"if Six Sigma is good enough for GE and other world class companies, why should we not consider it".*

Lean and Six Sigma were introduced in *C, D,* and *E* by their parent companies that believed in the concept of CI and have realized significant benefits from the implementation of Lean and Six Sigma. Parent companies of *C and E* believed in the efficacy of Six Sigma and encouraged the management team in *C and E* to implement the initiative with their financial and human resource support to train employees on Lean Six Sigma. Due to a change in leadership at the corporate level of *C* in 2001, the new CEO supported the application of Lean Six Sigma for minimizing wastes and defects across the organization and its subsidiaries including *C*. With the support of the parent company, *C* implemented Lean/Six Sigma across their production department to minimize waste and defects from their processes. Six Sigma was used as the main problem solving methodology for quality and cost improvement in *C*.

As *E* was involved in job shop production, rather than batch or mass production, they used basic problem solving methodology for process improvement. Six Sigma was introduced by the parent company and was only used when problem was complex enough to be solved using basic problem solving methodology. It would have been difficult for *D* and *E* to embark on initiatives such as Six Sigma, had it been not financed by the parent company. This was the opinion of interviewees in *D* and *E*. However, due to acquisition by larger firms, *C, D,* and, *E* had limited authority for decision making regarding their R&D and strategic issues. They were empowered to take operational improvement related decisions. The availability of resources for training of employees was one of the advantages of being part of a MNC as experienced by *C, D*, and *E*.

When CIP was introduced in 2002, *D* had support from the MD who was in regular touch with the project champion to monitor the progress of projects. However, things changed after he moved and the management structure changed both in *D* and the parent company. Lean was implemented in *D* by the new management team at corporate level and the focus shifted from standard procedures to a process perspective. *D* applied the principle of Lean in supply chain; started global customer initiative- getting in touch with customers; and established key performance indicators (KPIs) in the strategic plan.

Lean was implemented in 2004 with no rationale provided for implementation. Five employees were initially trained by experts from the parent company on Lean principles before getting started with the implementation. Only the middle management team went for the training with no participation from senior management level. The five trained personnel were responsible for all the process improvement activities in *D* and were also dragged into other day to day activities of the business.

D struggled to maintain the momentum after application of Six Sigma due to several changes in management at the corporate level. Six Sigma was introduced in *D* by the parent company in 2006 to minimize defects in their production department. A new CEO was appointed at corporate level who believed only in the concept of Lean to a certain extent (Six Sigma was not included in his business lexicon) and was primarily driven by profitability and increase in market share. This resulted in the loss of momentum of initiatives such as Lean/Six Sigma that had an immediate impact on the defects in processes/ products and on-time delivery of the products manufactured. Since the change of management, any investment in training on QM has completely stopped. The existing culture of the company after the change in management structure in 2007 is best illustrated from the following statement from the Quality Manager in *D*-

"We had a change in management structure that was not supporting our framework we followed in the past. We had different business units that were competing with each other. The parent company was only driven by numbers and wanted the desired results. However, they questioned us when there are customer complaints or we have not met delivery-time promised to the customer".

Table 7.4: Reasons to embark on CI initiative or certification system

	A	B	C	D	E
Motivation to implement existing QP	*Lean* - To improve the work-flow - Results are quickly visible - Good for the first round of improvement *Six Sigma* - To inculcate process thinking - Eliminate variation - Structured methodology - Projects linked to bottom-line - Customer- focused approach	*Lean* - Optimal utilization of work-space at new factory site - Minimize the waste *Six Sigma* - Some problems difficult to resolve using Lean tools - To reduce variation in the administrative processes - Good for resolving complex problems with unknown solution - Customer focus	*Lean* - No rationale provided for implementation. - Driven by parent company - Minimize waste from business processes - Improve image & Increase in market share *Six Sigma* - Driven by parent company - Change the mindset and thinking process of engineers and other employees - Improve image & Increase in market share	*CPI* - Establishing Standard procedures *Lean* - No rationale provided for implementation. - Driven by parent company - Minimize waste from business processes *Six Sigma* - Driven by parent company - Minimize defects	*Six Sigma* - Driven by parent company - Minimize defects - Solve complex business problems

7.1.2.4. Organizational Infrastructure

The term ‘organizational infrastructure’ refers to the number of trained quality personnel responsible for implementing Lean, Six Sigma or ISO and driving CI efforts in the company. The detailed information on organizational infrastructure existing in the participating firms was provided in table 7.5. To test the efficacy of Lean and Six Sigma on a pilot project, *A* and *B* trained their best people as Black Belt (BB) and Green Belt (GB) to carry out pilot projects. A team comprising these people were selected from cross-functional departments and were assisted by shop-floor employees (trained as Yellow Belt [YB]) to execute projects across the business functions.

‘A’ managed to secure funding (30% of the training cost) to get started with external Six Sigma BB training in the first year of the Six Sigma implementation. Two of their best employees were trained externally as BBs. BBs, took the train the trainer approach, to provide Six Sigma YB training to the rest of their employees to raise their awareness on the efficacy of methodology. *BBs in A were responsible for executing Six Sigma projects for a two year period and were thereafter rolled back to their original job. This rotation policy was used to give opportunity to other skilled staff members to undertake GB projects under the guidance of experienced BBs.* This rotation policy not only took care of their scarce human resources but also developed an infrastructure that was capable of sustaining the learning and benefits from the initiative on a long-term basis.

Similarly, *B*’s employees were trained as Green Belts from one of their customers (original equipment manufacturer [OEM]) at a discounted price. They also managed to get support from the DTI funded organization, North East Productivity Alliance (NEPA) that conducted a diagnostic check for the company to identify the gaps in their process improvement approach and suggested implementation of Lean for the first round of process improvement. The MD hired a Lean Six Sigma facilitator, having previous experience of implementing Lean Six Sigma in large organizations, to facilitate the implementation of Lean/Six Sigma and develop an organizational infrastructure to support the implementation of the initiative. The MD took the responsibility of controlling the CI initiative which was driven by shop-floor employees to make it more sustainable for the longer term. A Lean Six Sigma facilitator trained the rest of the organization on the basics of two methodologies. The MD of the company showed the commitment to the initiative by himself undertaking a GB training program and also executing a GB project, thereby leading by example. *B* had started applying the principles of Lean/Six Sigma outside manufacturing, i.e. in their administrative/ support processes such as HR and finance.

Due to a change in management at the parent company, *C* implemented Six Sigma to drive the CI effort with the support of a new and charismatic CEO from the parent company. BB training was provided by skilled trainers from the parent company to seven process engineers in *C* to implement Six Sigma within the production department. People showing interest in BB training were given opportunity to be trained and to execute projects. Eleven employees were also trained at GB level after the first wave of BB training but failed to execute any projects due to lack of self motivation and work pressure. Six Sigma was becoming endemic in *C*, with engineers using its principle in their day to day work for cost and quality improvement, fact based decisions and problem solving.

Lean was implemented in *C* with the help of the parent company and support from Scottish Manufacturing Advisory Services (SMAS) practitioners. SMAS practitioners trained engineers on Lean tools and the focus was particularly on streamlining the production department. *C* had again involved SMAS practitioners in 2007 to re-launch the Lean initiative across the business and got shop-floor employees trained on basic lean tools such as 5S or value stream mapping (VSM). The statement from the Operations Director in *C* reinforces the support they are getting from the parent company to drive CI – *"If we do recognize that we need to implement QI, we are always backed with investment in training"*.

C was developing their own capability to train the rest of the employees on Lean/Six Sigma so that they can sustain the culture of CI on a long-term basis. The statement below from the Quality Engineer in *C* further reinforces the aforementioned point – "*But from a local perspective, we are trying to develop a mentor type program, where engineers teach Lean / Six Sigma to the rest of employees. So that we can retain the knowledge and keep the momentum rather than relying on external consultants. One of the experts is involved with the employees on resolving problems at the shop-floor level, he introduces tools & techniques to the rest of the employees without directly telling them about Six Sigma or Lean*".

The Lean/ Six Sigma implementation pattern in *D* and *E* was similar to the approach adopted by *C*, i.e. implementation was facilitated with the support of the parent company. Corporate people entrusted divisional people in *D* to implement Lean and Six Sigma. The USA counterpart sent a Lean Six Sigma expert to train *D's* employees on Lean/ Six Sigma implementation. Two employees in *D* were trained on Lean/Six Sigma by the corporate team as GBs and were further supported by Scottish Enterprise (5-6 days training on Lean Six Sigma). There was 11-12 sessions on Lean training and thereafter employees were supposed to execute projects. *D* was sending 10% of the employees for a higher educational degree. Due to a change in the management structure of the parent company and appointment of a new MD, the focus in *D* shifted from Lean/Six Sigma to meeting productivity targets and enhancing profitability of the company. The focus on Six Sigma training or projects was lost and minimal investment was made by the parent company to build the organizational infrastructure in *D* to execute Lean/Six Sigma projects.

Six Sigma was implemented in *E* with the support of the parent company that initially provided a one day awareness session on Six Sigma to everybody in the company. Two process engineers were trained as GB and one middle manager was provided DFSS training. *E* had cross-functional process improvement teams of 4-10 members to brainstorm ideas and resolve the quality problems in their business processes. The MD of *E* was very committed to Six Sigma, underwent Six Sigma awareness training to become a project sponsor to support the CI effort in the organization. Again, there was pressure from the parent company to ingrain a culture of Six Sigma thinking within *E*. The next step in their CI journey was to train the best employees as BB, who can execute projects and train other employees in *E*.

Even without external support and funding, the MDs in both *A* and *B* were ready to commit resources for the training of employees as they realized that benefits generated (both hard and soft benefits) from Six Sigma implementation outweighs the initial investment cost. In the case of *B*, the training was supported by one of their key customers at a discounted rate. In *C* and *D*, the training support was provided by government funded bodies such as SMAS and Scottish Enterprise apart from their parent company. Interviewees in *E* were not sure how they would have trained their employees without the support of the parent company.

Table 7.5: Organizational infrastructure in Six Sigma SMEs

	A	B	C	D	E
No. of employees trained on Lean and Six Sigma BBs, GBs, YBs;	2 BBs (ET) 2 GBs (ET) All employees given Lean awareness training & YB training (IT)	1 BB (trained in previous job) 3 GBs (ET) 9 ongoing GB training (ET) All employees trained on basics of Lean/Six Sigma (IT)	7 BB (PC) 11 GB (PC) All employees trained on basics of Lean/Six Sigma (IT)	2 GBs (PC) All employees given Lean Six Sigma awareness training (PC) 10% staff funded initially for higher education degree	2 GBs (PC) 1 DFSS All employees given Six Sigma awareness training (PC)
Support received in training	30% funding from government body to kick start Six Sigma program	Training partly supported by their external customer	Training supported by parent company & Scottish Manufacturing advisory services (SMAS)	Training supported by parent company & Scottish Enterprise	Training supported by parent company

ET = External training, IT = Internal Training, PC = Parent Company

Interviewees in the five firms stressed the importance of networking with their key customers or OEMs, government funded bodies, and universities to facilitate knowledge transfer of CI activities for business process improvement. They have very little awareness of any support / funding available from Government bodies or academic institutions. When asked about awareness of government funded projects (partial funding) such as Knowledge Transfer Partnership (KTP) programs aimed at helping SMEs, none of the participating firms were aware of existence of such programs but were very enthusiastic and eager to know how they could avail such funding. Such programs may help SMEs to build their human resource and technical skills required for implementation of initiatives like Lean and Six Sigma.

7.1.2.5. Quality tools and techniques usage

In the interview with sample companies, interviewees were asked to mark the most common tools and techniques used for process improvement. The questions were divided in to three sections: basic tools of continuous improvement; management tools; and other tools and techniques (OTT) used to resolve the complex business problems. The details of the application of different tools and techniques were listed in table 7.6.

All the sample firms were in the early stage of implementing Six Sigma, i.e. having less than 5 years experience. This may have a direct implication on their usage of tools and techniques of quality / process improvement for resolving quality related problems in organization. The result from table 7.6 clearly reflects their inexperience in using management tools and tools within other categories. Mostly, all the sample firms, except *D*, were using basic tools of quality in day to day problem solving activities. As stated by quality Guru, Kaoru Ishikawa (1951), 95% of the problems in industry may be resolved using basic tools of CI. Basic tools of CI are visual tools (similar to Lean tools like 5S and value stream mapping [VSM]), which can be used by the average person or shop-floor employees to understand, analyze, and interpret data for process improvement.

A, B, and *C* used some of the tools and techniques within the OTT category while executing Six Sigma projects. BBs in *A, B,* and *C* were aware of the usage, usefulness and limitations of each tool and technique. Some of the Lean tools such as 5S, Kanban, and VSM, were used in *A, B,* and *C* for the initial round of improvement and achieve quicker results to get buy-in from shop-floor employees as well as senior and middle management teams. Moreover, Lean tools are visual and easier to understand from the layman's perspective, e.g. Kanban, 5S, VSM, as it involves less statistics and is very simple to use. Interviewees also opined that Lean tools like 5S and VSM gives a sense of empowerment to shop-floor employees to take decisions for their processes and improve their work space. The improvements from application of lean tools were quite rapid and visible, which helped in breaking down any resistance to change by the employees. Successful application of lean tools in *A, B,* and *C* provided a platform for implementation of Six Sigma as a culture of CI was ingrained in the three firms through company-wide involvement in the Lean initiative.

When it comes to application of Six Sigma tools and techniques in the OTT category, tools/ techniques such as SPC, FMEA, and regression analysis were used by majority of the participating firms except *D*. Powerful techniques like DoE, Balance Scorecard, Benchmarking, Quality Costing, QFD, hypothesis testing, TPM, were either rarely used or not used by participating firms for resolving quality related problems.

Table 7.6: Tools and techniques perceived to be currently used in sample SMEs

Tools & Techniques	A	B	C	D	E
Basic Tools					
Cause & Effect	×	×	×	×	×
Check Sheet / Tally Sheet	×	×	×		×
Control Charts	×	×	×	×	×
Histogram	×	×	×		
Pareto Charts	×	×	×	×	×
Scatter Diagram	×	×	×		×
Process Map	×	×	×	×	×
Brainstorming	×	×	×	×	×
Management tools					
Affinity Diagrams	×	×	×	×	×
Relations Diagram	×	×	×		
Tree Diagram	×	×			×
Matrix data analysis					
Matrix diagrams					
Arrow diagram			×		
Process decision program chart					
Other tools & techniques					
5S	×	×	×	×	
Kanban	×	×	×		
Benchmarking			×		
Balance Scorecard					
Statistical Process Control (SPC)	×	×	×		×
Failure Mode and Effect Analysis (FMEA)	×	×	×		×
Value Stream Mapping (VSM)	×	×	×		
Measurement System Analysis (MSA)		×	×		
Design of Experiments (DoE)	×		×		×
Quality Function Deployment (QFD)					
Hypothesis Testing	×				
Regression Analysis	×	×	×		×
Force Field Analysis					
Quality Costing	×	×			
Total Productive Maintenance		×			
Mistake Proofing		×	×		

D and *E* were struggling to use the management tools and tools within the OTT category to drive their CI efforts. As *E* had implemented Six Sigma for a year only, they have slowly started using advanced tools and techniques for Lean and Six Sigma projects. *E* had used DOE to change the entire design to manufacture guidelines across the printed circuit board (PCB), resulting in massive improvement and bottom-line impact.

The reasons cited for low usage of quality tools and techniques by the interviewees in *D* were lack of senior management focus on CI and limited employee understanding on the usage of these tools and techniques. *D* and *E* rarely used any of the advanced techniques for problem solving. It is noteworthy that all the participating firms were very new to the implementation of Six Sigma and thus not aquatinted with or applying advanced tools/techniques. Understanding of tools such as cost of quality or QFD is minimal in SMEs, as revealed from the case study analysis. It raises questions on how firms measure the VOC and translate this into technical requirements of the product. Only *B* was fully utilizing the concept of quality costing to measure the process performance across the business functions. *A* had recently involved the finance department to collate quality related costs incurred by the company. The calculation of the cost of poor quality may help *A* in minimizing waste from the organization by identification of Six Sigma projects which is imperative from the customer perspective (both internal and external). Taking account of quality costs is rarely observed in SMEs, i.e. those cost incurred in the design, implementation, operation and maintenance of a company's quality management system, the cost of resources committed to the process of continuous quality improvement plus the cost of systems and/or product failures.

7.1.3. Critical Success Factors and Barriers

7.1.3.1. Critical Success Factors (CSFs)

In the context of Six Sigma implementation, CSFs represent the essential ingredients without which a project stands little chance of success. Interviewees in the sample firms were asked to identify factors they considered important for successful implementation of Six Sigma. Factors listed as important are presented in table 7.7 and elaborated below.

Strong leadership and top management commitment

Success of any CI hinges on *strong leadership* and *commitment from top management* to devote time, resources, and break down stumbling blocks in the implementation process. In *A, B, C*, and *E*, the implementation of initiatives such as Lean and Six Sigma were supported by the MD of the company. The MDs in these firms communicated the need for the initiative by addressing the entire organization about the competitive advantages provided by Lean and Six Sigma. The MDs were very committed to keep the business sustainable on the long-term basis, resulting in the implementation of CI initiatives and allocating resources to drive improvements in performance, value and quality. In *A*, Six Sigma was included within the top three priorities of the business. Six Sigma was a part of everybody's job, including top management and senior managers. All the three Directors in *A* attended one day awareness training on Lean and Six Sigma to understand the mechanics of the two business strategies. This reflects on the commitment from the top management in *A.*

Providing a strong leadership, the top management team in *A, B, and C* made resources available for training employees, executing projects, were present in project review meetings and helped break down stumbling blocks during the project execution. The Six Sigma projects in *A* and *B* were always led by the senior management team, acting as project champions for those projects.

Customer Focus

CI initiatives such as Six Sigma start with capturing the true VOC and ends in enhancing customer satisfaction. Similar practices were observed in the participating firms *A*, *B*, *C*, and *E* – allocating a dedicated resource to be in contact with major customers on a one-to-one basis to understand their requirements and develop a long-term relationship with them. Both in *A* and *B,* the MDs would personally visit some of their key customers and keep track of orders being delivered on-time. Initiatives like Lean and Six Sigma had helped the sample firms to improve their quality of product and on-time delivery rate, thereby enhancing customer satisfaction. Other methods used to capture customer requirements were surveys, personal visits, and in some cases customer complaints. The interviewees in *C* mentioned securing multi-million contracts with one of their key customers (*C* had failed in the past to get a contract with this customer due to poor product and service quality) due to improvement in processes and quality of products as a result of Six Sigma implementation. *D* was not meeting customer requirements nor achieving delivery schedules on many occasions, leading to customer dissatisfaction and losing some major customers. The nature of business in *E* requires the middle and senior management teams to meet their key customers personally as they manufacture customized hardware fulfilling their customer requirements.

Culture change

The implementation of Six Sigma resulted in significant changes in the working culture of *A, B, C, and E*. The first and the foremost change observed in the sample firms were decisions based on fact and data rather than gut feelings. *A* and *B* had improved significantly in the data collection process by empowering and involving shop-floor employees to improve their own processes. Middle managers in *A* and *C* had involved shop-floor employees to collect data and improve their workplace by applying the tools of CI, 5S, and VSM. Six Sigma had facilitated in transition from reactive mode of operation to proactive mode, to get the product /service right first time. As said by the Lean Six Sigma champion in *B* - "*Everybody is very overworked. If the Six Sigma project is coming their way, it is sometimes seen as extra work coming on top of their daily work. But generally, as the project is focused on improving something, like fire fighting for them, they conceive it will benefit them in long run*". Company-wide involvement in *A, B,* and *C* allowed employees to understand what their areas are delivering, helped them in identifying the bottleneck; established consistency in working procedures; enabled cross-functional team formation for projects and audits across the firm. Another change observed in sample firms were quantification of benefits generated from CI projects (which was not practiced before embarking on Lean/Six Sigma journey) and communicating it to the entire organization to get their buy-in and commitment for the change.

Communication

A communication plan is important in order to involve personnel with the Six Sigma initiative by showing them how it works, how it is related to their jobs and the benefits that will arise from it. Communication from the top facilitated in breaking down any resistance for change in the company in all the sample firms. In *A* and *B*, the need for Six Sigma was communicated through emails and presentations to all employees by the MDs. The MDs communicated with employees in a quarterly general meeting and updated employees on the progress of Six Sigma projects in the company.

Other communicating mediums used in the company were newsletters, notice boards, e-mails, away days and meetings. In his message, the MD of *A* said that the company is committed to Six Sigma for the next six years and it is the need of the hour to implement Six Sigma for being globally competitive. In order to get buy-in from employees, the MD and Finance Director (FD) in *A* acted as champions of pilot projects using Six Sigma DMAIC methodology and conveyed the benefits generated from the pilot project across the company. The commitment from the MD and other senior management people in '*B'* was reflected from the MD's statement presented below– "*We try to keep the initiative live by doing the monthly audit of 5S each month. It is done by two of our directors. We change the location of the audit. By doing that, we maintain top level company awareness of what is happening in the business; talking to people and understanding their difficulties; it enables and generates awareness for everybody what is going on in the business*".

In *A, B, C, and E*, an email was send at the end of the Six Sigma project to brief the rest of the employees on what happened in the project. Other communication mediums used were notice boards, quarterly newsletters, messages displayed on TV screen in canteen during breakfast and lunch breaks, project review meetings, and the MD's address to the rest of the employees from time to time. The communication mechanisms in *D* were also very similar but the focus was more on productivity and sales metrics rather than communicating information on the benefits on any CI projects.

Commitment from middle-level management

This was the new factor, which was missing from the existing literature on CSFs of Six Sigma and which emerged from the interview process. In *A*, *B*, and *C*, initially it was difficult to convince the middle managers to get involved in Six Sigma project execution. Team leaders were difficult to convince to release the people within their departments for the project execution as they had to find a replacement for the person engaged in the project. This problem was resolved involving the senior management team and making the team leaders realize the benefits the department will have from the success of the project. Quotes from the Lean Champion in *'B'* further reinforces the aforementioned point – "*No resistance at the middle level management as because of the involvement of the MD; discussing with them and letting them know the reason as why we are doing it*". Once the benefits from the pilot project were shared with middle level management, the resistance to change started to wane.

Employee training and involvement

Interviewees in the five firms believed that to build and sustain a culture of CI, it is imperative to train your employees on the basics of Lean and Six Sigma and get them involved from the inception of the quality program in the firm. As discussed in the previous section, some of the quality initiatives failed due to minimal involvement of shop-floor employees during the early implementation stage or lack of training and knowledge about the initiative. Employees are the real 'action heroes', who are involved in daily production/ service delivery. Training and empowerment would facilitate employees to take decisions for their own processes and make improvement in their processes. As observed in *A*, *B, and C*, the majority of the shop-floor employees received one-two days introduction training on Lean/Six Sigma, were given process ownership, and freedom to share and suggest ideas for process improvement with their supervisors or middle management. Employee empowerment and involvement in CI initiatives facilitated in changing the working culture in the three firms. The Operations Director in *C* commented on the employees commitment to Six Sigma program - "*We have been fortunate in the business our people have been ready not only to show their commitment but also apply their commitment. For example, we had more than 11 volunteers opting for Six Sigma training, showing their interest in the Six Sigma training".*

Availability of resources

To ensure the success of any initiative, it is imperative for the top management to make resources available for the project execution. The literature reveals that SMEs struggle with any new CI initiatives due to limited resources for training and executing projects. Interviewees in the five sample firms were not in consensus with the findings from the past literature and argued strongly that *leadership and management commitment to resources governs the success of any new initiative*. Though interviewees agreed that SMEs have limited resources, but development of best-in-class practice will create some slack resources that could be used in implementation and deployment of CI initiatives for long term sustainability. Scarcity of resources is just an excuse from the top management not to implement quality initiatives and still continue working in a fire-fighting mode to tackle the mundane problems rather than being proactive in its effort to CI. '*A'* with 36 employees had managed to roll-out Six Sigma across the business due to strong leadership and management commitment. It was indeed a heavy investment in training BBs and GBs, but the savings generated from the projects outweigh the investment made. Interviewees in the sample firms (especially MDs in *A, B,* and *C*) were in consensus with the aforementioned statement.

Networking

Interviewees in *A, B* and *C* commented on the role of local universities / government bodies in supporting SMEs to embark on CI initiatives. The partial government funding encouraged *A* to train more employees on Six Sigma. Support from their customer facilitated *B* to train ten of their employees as Green Belt. *C* was also receiving support from a government funded organization to implement Lean tools such as 5S and VSM. *A* and *C were* interested in collaborating with local universities in the near future to learn more about CI initiatives. *E*mployees in *A* and *B* never supported the idea of bringing in an external consultant for Six Sigma training, who would require large up-front payments and provided temporary solutions for their everlasting problems. From economy and long-term sustainability perspectives, collaboration with local universities through programs such as KTP was considered imperative for the SMEs success.

The most common factors cited across the five firms were: *strong leadership; education & training; employee's empowerment; communication; customer focus; data collection & measurement; and networking*. These factors have appeared three or more times in table 7.7 based on interviewees responses.

Table 7.7: Factors critical to the success of Six Sigma initiative in sample firms

	A	B	C	D	E
Critical success factors	• Strong Leadership • Commitment from top management • Commitment from the middle managers • Education and training • Communication • Empowerment • Cross-functional team • Networking • Involvement of accounts & finance deptt.	• Commitment from the top level • Culture • Senior Management buy-in • Cross-functional team • Empowerment of workforce • Communication • Full-time Facilitator to drive and manage QI • Education and training • Customer focus	• Leadership • Education & training • Empowerment • Networking • Role of Middle manager • Data Collection & Measurement • Communication • Customer focus • Availability of resources • Understanding of CI initiatives • Involvement of accounts & finance deptt.	• Leadership • Communication • Strategic Vision • Data Collection & Measurement • Role of Middle Manager • Investment in employees education & training	• Leadership • Employees Education & training • Networking • Resource Availability • Customer focus • Culture change • Understanding of CI initiatives • Data Collection & Measurement

Analyzing the qualitative data collated through interviews, observations, company reports, and results from previous sections, table 7.8 was constructed to compare the positioning of the five firm's w.r.t. the aforementioned seven factors.

Table 7.8: Relative positioning of firm's with respect to CSFs

Most commonly cited CSFs	A	B	C	D	E
Strong Leadership	++	++	++	--	+
Education & training	+	++	++	-	+
Employee's empowerment	++	+	+	-	+
Communication	++	++	+	+	+
Customer focus	++	++	+	+	+
Networking	+	+	+	-	-
Data collection & measurement	+	+	+	-	+

++ = strongly present; + = moderately present; - = weak presence; -- = Minimal presence

Taking cue from previous section results, each factor was rated qualitatively (from strongly present to minimal presence of CSFs in each firm) against the five Six Sigma firms. The ratings presented in table 7.8 were based on the author's analysis of qualitative data and comprehension of key findings from previous sections. *A, B, and C* had strong presence or moderate presence of most CSFs (especially all three firms exhibiting strong leadership). Due to a change in management structure and focus recently, *D* was struggling to keep alive its CI journey of Lean/Six Sigma due to weak or minimal presence of the aforementioned CSFs. The management team in *E* had realized the importance of Six Sigma and is making every effort to raise awareness of the initiative and sustain the benefits realized from Six Sigma on a long-term basis (this was reflected in *E*'s rating across the seven CSFs in table 7.8).

7.1.3.2. Challenges faced in the implementation of Six Sigma

There are several barriers and challenges identified from the literature, including the *lack of management commitment, strong leadership, resource availability and resistance to change*. Similar findings have also been reported in this study. Lack of strong leadership and management commitment resulted in the failure of Lean and Six Sigma initiatives in *D*. Due to the change in management structure, shift in management focus and takeover by a MNC, the initial buy-in in Lean and Six Sigma faded away slowly in *D.* Management commitment to quality in *D* after take over by a MNC was considered ambivalent- on one hand they were very committed to provide quality products to customers on time; but in fact their commitment to quality program could be described as assigning their name to a quality policy document, attending the annual quality management review meeting, and adhering to operational procedures. These actions seemed to be the maximum commitment they were prepared to make. There was no clear direction or evidence to suggest that senior and middle management were actively committed to the concept of CI. Other four sample firms had full support from top management as discussed in previous sections and thus the change was smooth, moving from reactive mode to proactive mode of operation. Another typical challenge experienced by the Black Belts was the *pressure from the Champion to roll out 2-3 projects in a year as well as undertake daily tasks.* Such projects were bound to fail due to attention being divided between daily jobs and the Six Sigma project, which further impacts on a BB's commitment to project execution and completion.

A summary of key challenges faced in the sample firms are listed in table 7.9. Some of the other challenges faced during the implementation process in the sample firms were:

- *Challenge of resource availability:* All the sample firms listed time and financial constraints as a major challenge in implementing initiatives like Six Sigma. The time required to train employees to make sure that they have competence and full capability to take on those quality responsibilities is very demanding. The MDs in the sample firms expressed their concern in training their best employees as Black Belt, which required significant time and financial resources. Thereafter, if the Black Belt left the company for a higher position and salary (which is a common practice observed in the industrial world), it would create a talent void in the company and it would be difficult to reinvest in training a Black Belt again. The CI effort was sometimes pushed back due to emergence of new priorities or lack of resources to complete the project. The statement from the Lean Champion in *B* provided a good insight into the problem of resource constraints –"*There is a resource problem. It partly depends on how profitable your business is. If you are already achieving profit, you can commit resources for Six Sigma. Given that it* *needs everybody's' commitment and activity and even if you are cash rich, you still need to find time to work on it. That is not an easy thing. It depends on how willing people are to find time to work on it out with from their normal hours*".

The biggest challenge identified was the issue of resources in the small companies such as *A* and *E*. As Director acts as a project Champion for all Six Sigma projects in *A*, which makes it difficult to find time to be available at all project review meetings. In such scenario, *A* had adopted the strategy of running one project at a time to get full commitment from the Director. One of the typical characteristics of smaller firms is the realisation of benefits from CI initiatives in a short time period, which is not always possible. It therefore becomes a barrier to wait and realise the outcomes in the longer term.

- *Challenge of quantifying the savings generated from Six Sigma projects*: It is very important to communicate the hard-dollar savings generated from Six Sigma projects to buy-in commitment from senior management and the rest of the employees. Interviewees in *A, B*, and *E* agreed that quantification of benefits from the Six Sigma project was challenging to evaluate, especially the hard-dollar savings in both short-term and long-term after the completion of project. The recent involvement of the Finance Director (FD) and people from the accounts and finance department in *A* and *B* had facilitated in quantifying the short-term and long-term benefits generated from the project that included both the hard and soft savings from Six Sigma and other CI projects. It was challenging to have the FD present at all the Six Sigma project meetings. Sometimes due to the busy schedule of the FD, there was some delay in project meetings and that is part of reason why some projects stretches to seven or eight months.
- *Challenge for conveying the reason to implement Six Sigma*: Employees in any organization see new change management initiatives as a threat to their job. It is imperative from the management perspective to dispel this threat by addressing all employees before embarking on any new initiative. As discussed in the previous section, before introduction of initiatives like Lean and Six Sigma in the sample firms, management teams held a debriefing session with employees to explicate the need for change and how it can help them to improve efficiency and profitability of the firm. As suggested by the MD of *A, any employee layover or*

redundancy program should be executed before the start of any new initiative in the company to buy-in employee commitment and negate their job loss fear.

- *Challenge of convincing the various department heads to get employees released from their department to work on the Six Sigma projects for 4-6 months*: This was a new factor emerging from the study that was not clearly listed in the Six Sigma literature. All the sample firms faced the challenge of convincing their middle management team to release members from their team for off-site Six Sigma training or involvement in Six Sigma projects for 4-6 months (as the manager has to find cover). *D* failed to get the commitment from the middle management team due to lack of support from senior management in allocating resources for employee involvement in CI projects.
- *Challenge of involving and empowering the employees*: One of the typical challenges observed in the case study firms was giving access to everybody in the team who were potential stakeholders and allowing them to make demands of other employees in terms of data collection, talking about procedures, identifying waste and where the improvement could be made. A huge amount of commitment by other stakeholders was required for the success of the initiative. Lack of commitment from employees will lead to failure of CI efforts in the firm.

Table 7.9: Challenges faced by firms to implement and sustain Six Sigma initiative

	A	B	C	D	E
Challenges Faced by Sample firms	• Role of middle managers • BB or GB getting involved in other work • Resource availability • Quantification of benefits from Six Sigma program	• Complacency • Training • Quantification of benefits from Six Sigma program • BB staying in the company for long-term • Employee empowerment	• Allocation of resources • Networking opportunity • Only training engineers on BB program • Employee empower. • Role of middle managers	• Change in mgmt. • People prefer to remain in Status quo • Lack of vision • Lack of senior mgmt commit. • Resource availability • Poor training & coaching	• Job-shop production • Quanti. of benefits • Role of middle managers

7.1.4. Impact of Six Sigma on Organizational Performance

In order to understand the relationship between Six Sigma and organizational performance, interviewees were requested to explicate the changes observed in the firm after implementation of Six Sigma. The focus of enquiry was not only on the hard benefits (e.g. increase in sales, profit, productivity, market share; decrease in scrap rate, defects; on-time delivery etc) but also on the soft benefits (e.g. customer satisfaction, employee satisfaction, change in thinking process, proactive measures for problem solving, decisions based on data, understanding of CI initiatives, good top-down communication, etc) generated from the implementation of Six Sigma initiative. Interviewees were explained the key constituents and differences between hard and soft benefits in order to capture detailed information on organizational performance. The result presented in this section summarizes the collective opinion of interviewees and the company reports of sample firms.

As discussed in the previous section, interviewees expressed difficulty in quantifying benefits generated from the Six Sigma program due to their limited experience in implementing and executing Six Sigma projects as well as lack of involvement of people from finance departments. This led the author to use a qualitative technique to measure the impact of Six Sigma on performance in sample firms. Based on interviewees' understanding of hard and soft benefits, they were asked to rate the overall improvement in hard factors and soft factors after Six Sigma implementation as *'significant improvement'* (++), *'some improvement'* (+), *'mixed result'* (+-), *'no improvement'* (-), and *'negative improvement' (--)*. It can be observed from table 7.10 that Six Sigma was '*very effective'* in improving the organizational performance of *A* and *C*. The MD of *A* stated the following while commenting on the cultural change in his firm– *"….Six Sigma person is not working alone they gather a team together in the area of the company. The team learn so much more about their job because they see how things work. People in the company understand more about their job, end in doing better job…we start to get lot more buy-in …the whole company looks together….the people on the shop floor benefited immensely from it….. "*.

Similar results were observed in *B,* and *E*, in terms of hard and soft savings generated by firms after the implementation of the quality program. Both *B and E* were in the early stages of implementing Six Sigma with less than two years of experience when data was collected. Since the implementation of the Six Sigma program in *D*, their performance has declined significantly. As discussed in earlier sections, the decline in performance of *D* is due to the change in management structure and shift in focus of top management on profitability improvement rather than enhancing customer satisfaction. The Quality Manager in *D* stated that "*there is nothing wrong with Six Sigma. The decline in performance could be attributed to lack of management commitment and focus on CI initiatives; lack of education and training opportunities for employees*".

Table 7.10: Hard and soft benefits realized by firms after implementing Six Sigma

Improvement after Six Sigma implementation	A	B	C	D	E
Hard benefits (*increase in sales, profit, productivity, market share; decrease in scrap rate, defect; on-time delivery etc*)	++	+	++	-	+
Soft benefits *(customer satisfaction, employee satisfaction, change in thinking process, proactive measures for problem solving, decisions based on data, understanding of CI initiatives, good top-down communication, etc)*	++	+	++	-	+

++ = significant improvement; + = some improvement; +- = mixed result; - = no improvement; -- = negative improvement

7.1.4.1. Soft Benefits observed in sample firms

It is difficult to measure soft savings from Six Sigma projects as most of the factors are intangible to measure. A similar approach to above section was taken to get detailed information on the soft benefits realized by firms after Six Sigma implementation. There was significant change in the working culture of *A, B, C, and E* after implementation of Six Sigma, as discussed previously in Section 7.1.3. Typical changes observed in the sample firms were improvement in top-down and bottom-up communication, decisions based on facts and data, investment in employee education and training, development of metrics to monitor the performance of a process, formation of cross-functional teams for Six Sigma projects, and in some cases involvement of accounts and finance departments in all Six Sigma projects. The details of soft benefits realized by sample firms were listed in table 7.11.

Table 7.11: Soft Benefits realized by firms after Six Sigma implementation

Soft Benefits	A	B	C	D	E
Increase in customer satisfaction	++	+	+	--	+
Increase in employee satisfaction	++	+	++	-	+
Decrease in employee grievances	+	*NA*	+	--	*NA*
Decision based on facts and data	++	+	+	+-	+
Established performance metrics	++	+	++	+-	+
Top-down and bottom-up communication	++	+	+	-	+
Organizational learning through sharing of benefits and challenges experienced during projects	+	+	+-	-	*NA*
Cross-functional teams for Six Sigma projects	++	++	+-	-	+
Involvement of people from accounts & finance	+	+-	++	*NA*	*NA*
Development in human capability to sustain the benefits	+	+	*NA*	-	*NA*
Employee empowerment and process ownership	++	+	+-	-	+
Investment in education & training	++	++	++	+-	++
Regular Internal Audit	+	++	*NA*	*NA*	*NA*
Understanding & usage of CI tools & techniques for problem solving	++	+	+	-	+-
Proactive approach to problem solving	++	++	++	-	++

++ = significant improvement; + = some improvement; +- = mixed result; - = no improvement; --= negative improvement; NA= not applicable

The results presented in table 7.11 were in consensus with table 7.10, confirming significant/some improvement in soft factors in *A, B, C*, and *E* after Six Sigma implementation. Firms like *A* and *B* have taken the *'train the trainer approach'* to build their own human capability for long-term sustainability of benefits realized from Six Sigma implementation. On the contrary, *C and E* being part of a MNC don't have resource constraints for education and training of employees. As such, the concept of the *'train the trainer approach'* is at its infancy in both the firms. The Operations Director in *C* had recently stressed the importance of developing their own capability to train employees on Lean and Six Sigma for long-term sustainability of the CI initiatives in the firm. Stressing the soft benefits from the employees' perspective, the Operations Director in *C* stated that – *"The learning itself for the people involved in* *that project outweighs the savings. They subsequently apply these tools & techniques in everything they do. Over a period of time, you will get more than you invest. More than that, you have standardization, consistency, a way of thinking, a way of working for the whole business"*.

7.1.4.2. Hard Benefits observed in sample firms

Interviewees were also asked to quantify the improvement in their existing performance metrics as well as bottom-line impact after the implementation of Six Sigma / Lean initiative in their firm. Examples of typical improvements that can be achieved through Lean and Six Sigma were demonstrated in table 7.12 and table 7.13. The tables were developed by collating information from interviewees in *A*, annual reports and observations during the site visits. As a result of the utilization of Lean tools and techniques, there was significant improvement observed in *A,* as demonstrated in table 7.12. This resulted in both hard and soft savings for the company over a period of time. The table gives examples of the type of Lean projects a SME could undertake for process improvement.

Table 7.12: Benefits from Lean implementation in '*A'*

Project	*Hard Savings*	*Soft Savings*
Reducing Changeover time	*30% reduction*	• *Increased employee efficiency* • *Cleaner and safer work environment* • *Proactive approach to problem solving* • *High job retention* • *High Employee satisfaction* • *Improved technical support process*
Reducing rework on purchase orders	*50% reduction*	
Reducing technical support enquiries	*15% reduction*	
Reduction in floor space utilization	*£10 k / year*	
Reduction in Scrap rate	*84% reduction*	
Reduction of raw materials and finished goods inventory	*30% reduction*	

Since *A* started implementing Lean, all core processes from receipt of order to dispatching was mapped, resulting in improvements in throughput and overall equipment effectiveness (OEE). The implementation of 5S resulted in re-organization of the manufacturing line, which in turn brought savings of over £10k per annum. Some of the other improvements through Lean initiative were depicted in table 7.12.

Examples of Six Sigma projects executed in *A* and their impact on the business was presented in table 7.13. The degree of improvement observed after implementation of Six Sigma projects were significant, ranging from immediate improvement in OTIF by 28% to immediate reduction of solder shots (i.e. defects in printed circuit boards) by 98%. Such an improvement is massive from a SME perspective as it can utilize the savings generated from those projects in the development of the firm as well as its employees.

Table 7.13: Impact on the business from Six Sigma implementation in *'A'*

Project	***Impact on the business***
Improving on time in full (OTIF) for sales order delivery	Immediate improvement by 28%
Improving raw material stock accuracy	51% reduction
Improved finished good stock accuracy	87% reduction
Reduction of solder shots	Immediate reduction by 98%
Reduction of sales order defect	Currently in progress

Since the implementation of Six Sigma, *A* had executed five projects that had significant impact on customer satisfaction and *bottom-line savings of over £180,000*. Some of the other benefits from Six Sigma projects were discussed in table 7.13. Similarly *B* had finished *6 Six Sigma projects in the manufacturing area that have resulted in savings of over £200,000*. The *benefit from the Lean implementation through 8 mini projects was estimated at over £150,000*. Lean Six Sigma methodology was used in *B* to resolve complex problems in the manufacturing area (leading to reduction in defect from 15% to 2%), new product development process and recently in administrative processes. The management team had struggled to quantify benefits from the new product development project and the projects in administrative departments. The above savings from Lean/Six Sigma projects were the *projected tangible figures*, evaluated by senior and middle management teams in *A and B, with minimal involvement of accountants or finance executives.* The actual savings from aforementioned projects would be much higher over a period of time than projected savings. In *C,* Six Sigma projects have had cost benefit analysis carried out by its accounting and finance department. The finance people continue to monitor the benefits generated from projects on a long-term basis. Significant decrease in defects (from 11% to 1.5%) was observed resulting in an increase in production rate, meeting on-time delivery targets, and improved customer satisfaction. *Black Belts in C have completed 10 Six Sigma projects, with an estimated saving of £35000 per project*. Unlike many large organizations, where a typical BB project saves approximately *£75000,* the savings from a BB project in *SME environment may* range from *£30000 - £40000 depending upon the type and annual turnover of SME.* This viewpoint was shared by interviewees in *A, B, and C*.

D failed to realize any hard savings from implementation of Lean and Six Sigma due to reasons mentioned in the earlier section. Six Sigma was not included within the top objectives of the business and there was no alignment with the strategic goals of the company. As commented by the Quality Manager, "*Lean and Six Sigma were not integrated with D's Quality Management System. There was no connection between performance metrics and Six Sigma".*

E had realized improvement in customer return rates from the field by 10%, on-time delivery by 8%, defects rate by 4% due to strict adherence to their previous quality management efforts and implementation of Six Sigma. *E* had conducted one Six Sigma project on new-product introduction process but the savings generated from the project were not quantified at the time of interview. The other reason for not quantifying the benefit was minimal involvement from the finance department in cost-benefit analysis at this small company.

Interviewees in the case study companies were asked, towards the end of the interview process, to rate on a Likert scale of 1-5 the benefits their organizations have experienced following the implementation of quality initiatives. Table 7.14 shows the degree of improvement realized on 1-5 scale after the implementation of Six Sigma.

Table 7.14: Evaluation of firm's performance against the performance indicators

	Performance Evaluation of companies on the 1-5 Likert scale questions				
Performance Indicators	**A**	**B**	**C**	**D**	**E**
Reduction in scrap rate	5	4	3	1	4
Reduction in cycle time	4	3	4	2	3
Reduction in delivery time	3	3	3	2	3
Increase in productivity	4	4	4	2	4
Reduction of costs	4	5	4	1	4
Increase in profitability	4	4	4	1	4
Improved sales	4	5	4	1	3
Reduction of customer complaints	4	3	3	2	4
Reduction of Employee Complaints/Grievances	3	3	3	2	3

1 = negative benefit / improvement; 2 = no benefit / improvement; 3= some benefit / improvement; 4=significant benefit / improvement; 5 =Crucial; *6 = measure not-used*

The table gives information on the performance metrics existing in the company and the improvement realized after the implementation of program. It can be seen from table 7.14 that *A* and *B* have realized significant improvements in the operational [includes reduction in scrap, cycle time, delivery time, and increase in productivity] and strategic measures [includes increase in sales and profit and reduction of costs] of organizational performance from the implementation of Six Sigma. As *B* and *E* had implemented Six Sigma in 2007, they have started realizing the improvements in the established performance metrics. Negative benefit or no benefit was recorded in *D* after implementation of Six Sigma. The scores in table 7.14 indicate a relationship between CSFs and performance improvement. As observed from the findings in Section 7.1.3, factors critical to the success of the Six Sigma program were present in greater extent in A, B, C, and E compared to D. This reflects on the difference in performance of *D* compared to other four firms. However, statistical validation is required to test the degree of association between CSFs and organizational performance, which is not within the scope of this research.

Table 7.15 summarizes the key findings from the five Six Sigma firms.

Table 7.15: Summary of key findings from the Six Sigma firms

	A	B	C	D	E
Current CI initiative in the firm	▪ Six Sigma ▪ Lean *Both program successful*	▪ Six Sigma ▪ Lean *Both program successful*	▪ Six Sigma ▪ Lean *Six Sigma successful; Investing more in Lean training*	*Struggling to maintain momentum* for Lean and Six Sigma program	Six Sigma -*A new CI initiative in the firm gaining popularity & momentum*
ISO 9000 foundation to embark on Six Sigma	**Yes -** *ISO does not guarantee quality in product but helps in standardising the process and follow it before embarking on Six Sigma*	**Yes -** *ISO helped to establish the structure, implement procedures and worked as a foundation to get started with Lean and Six Sigma*	**Yes -** *Impossible to implement Lean /Six Sigma without having established process and procedures in place*	**Not Sure -** *employees looked at it as bureaucratic and time consuming. It established the procedure; but hinders innovation and creativity as you adhere to the procedure.*	**Yes -** *ISO is effective for keeping people working to procedures; establishes a disciplined system to facilitate Six Sigma implementation.*
Motivation to implement Six Sigma	▪ To inculcate process thinking ▪ Eliminate variation ▪ Structured methodology ▪ Projects linked to bottom-line ▪ Customer- focused approach	▪ Some problems difficult to resolve using Lean tools ▪ Reduce variation in the administrative processes ▪ Good for resolving complex problems with unknown solution ▪ Customer focus	▪ Driven by parent company ▪ Change the mindset and thinking process of engineers and other employees ▪ Improve image ▪ Increase in market share	▪ Driven by parent company ▪ Minimize defects	▪ Driven by parent company ▪ Minimize defects ▪ Solve complex business problems
Organizational Infrastructure	▪ 2 BBs; 2 GBs ▪ All employees given Lean awareness training & YB training	▪ 1 BB; 3 GBs; 9 ongoing GB training ▪ All employees trained on basics of Lean/Six Sigma	▪ 7 BBs; 11 GBs ▪ All employees given Lean awareness training	▪ 2 GBs ▪ All employees given Lean Six Sigma awareness training	▪ 2 GBs; ▪ 1 trained on DFSS ▪ All employees given Six Sigma awareness training
Quality tools & techniques usage	Knowledge of and uses basic tools of CI; Uses some mgmt. tool; Tools within OTT used to resolve quality related issues; Other quality tools like QFD, TPM, MSA not understood	Knowledge of and uses basic tools of CI; Uses some mgmt. tool; Tools within OTT used to resolve quality related issues; Other tools like DoE, QFD, hypothesis testing not understood	Knowledge of and uses basic tools of CI; Uses some mgmt. tool; Tools within OTT used to resolve quality related issues; Other tools like TPM, QFD, quality costing, hypothesis testing not understood	Little knowledge and usage of basic tools & mgmt. tool; Tools within OTT seldom used	Knowledge of and uses basic tools of CI; Uses some mgmt. tool; Tools within OTT used to resolve quality related issues; Less usage of tools within OTT as they have just started on Six Sigma journey
Critical Success Factors (Top five)	▪ Strong Leadership ▪ Communication ▪ Education & training ▪ Employee empowerment ▪ Cross-functional team	▪ Senior Mgmt. commitment ▪ Culture ▪ Education & training ▪ Customer focus ▪ Full-time Lean Six Sigma Facilitator	▪ Strong Leadership ▪ Education & training ▪ Employee empowerment ▪ Availability of resources ▪ Customer focus	▪ Leadership ▪ Communication ▪ Education & training ▪ Strategic Vision ▪ Role of Middle Manager	▪ Strong Leadership ▪ Education & training ▪ Networking ▪ Availability of resources ▪ Customer focus
Challenges / Barriers	▪ Role of middle managers ▪ BB or GB getting involved in other work ▪ Resource constraints ▪ Quantification of benefits from Six Sigma program	▪ Complacency ▪ Training ▪ Quantification of benefits from Six Sigma program ▪ BB staying in the company for long-term ▪ Employee empowerment	▪ Allocation of resources ▪ Networking opportunity ▪ Only training engineers on BB program ▪ Employee empower. ▪ Role of middle managers	▪ Change in mgmt. ▪ Maintain Status quo ▪ Lack of vision & commitment from senior mgmt ▪ Resource constraints ▪ Poor training & coaching	▪ Job-shop production ▪ Quantification of benefits ▪ Role of middle managers
Impact on Organizational Performance	**Sig. +ve impact** on *Hard & Soft* performance metrics after implementation	**Sig. +ve impact** on *Hard & Soft* performance metrics after implementation	**+ve impact** on *Hard & Soft* performance metrics after implementation	**No impact** on *Hard & Soft* performance metrics after implementation	**+ve impact** on *Hard & Soft* performance metrics after implementation

7.2. Findings from Non- Six Sigma firms

7.2.1. Demographic Details of non-Six Sigma SMEs

Company F employed 2200 employees in the late 1970s, being the sole market leader in providing appliances for boilers and central heating. It currently employs 86 people with an annual turnover of £6.5 million. Its products, ranging from room and hot water thermostats to central heating programmers, represent over 60 years of excellence in serving the domestic heating industry.

Company G was formed in 2002 after splitting from its parent company that had been in business for nearly 70 years. The parent firm employed 300 people in 1977, and the headcount of *G* after the split was 88. The company manufactures products that range from different types of papers (including adhesives and liners), to thermally coated tags and tickets for the food industry, airline ticketing and other packaging industries.

Company H started in 1988 with 14 employees and currently employs over 105 full-time employees and 60 agency staff across three shifts. Its primary business is the manufacture of toiletries products including a variety of soap tablets (250 different products), filling of scented and aromatic oils, and perfumes in the ratio of 50: 10: 40. It also assembles and packages the aforementioned products as gift pack for different occasions as demanded by its key customers. Its major customers are The Body Shop and Sainsbury.

Company I is a family owned business since 1960 within chemical industry and employing around 190 workers (out of which 90 are full-time employees). It manufactures chemical products for its major customers in the chemical and pharmaceutical industries and is also responsible for warehousing and distribution of packaged chemicals. Its efficient management of logistics operations and distribution management has provided opportunity for it to serve most of the major names in global chemical and pharmaceutical industries.

Company J was established in 1992 by two people and currently employees 25 full time workers manufacturing cables and wiring harness for customers in the electronic and aerospace industries. The company manufactures in batches, which are repeatable, and use low volume- high mix cables. They also manufacture connectors for different equipment, e.g. connecting one circuit board to another or connecting one equipment type to another. Products were customized to the requirements of its major customers and it also provided support to their customers in improving the design of their wiring and harness.

Other demographic details of companies were provided in table 7.16.

Table 7.16: Demographic details of the non-Six Sigma firms

Company	Manufacturing Activity	Company Type	Annual Sales Turnover	Location	Number of employees
F	Electrical	Independent	£6.5 m	Scotland	86
G	Paper, printing& packaging	Independent	£20 m	Scotland	88
H	Toiletries	Independent	£10 m	Scotland	165
I	Chemical	Independent	-	England	190
J	Electrical	Independent	£1m	England	25

7.2.2. Quality Management Practices in SMEs

7.2.2.1. History of Quality Initiatives

F and G had undertaken ISO 9000 accreditations in order to sustain their businesses in the global market. Both of these companies have existed for more than 50 years, witnessing several changes in management, acquisition and merger into different groups, and transition in size from large organizations falling into the SME category. *F* used inspection based quality system to monitor the quality of raw materials from suppliers. They also make sure that their suppliers have ISO 9000 certification. *F* had recently started applying Lean tools such as 5S and Kanban, with the support of the Scottish Manufacturing Advisory Services (SMAS).

G tried to launch TQM in 1994 but *failed* to reap the benefit *as the initiative was led by a single person*, i.e. the Technical Director of the company. There was no transferability of the learning after the retirement of the Technical Director in 1995. A group of people who supported the initiative does not had the decision making power to take the initiative further. After a change in management structure, *G* went through ISO 9001: 2000 accreditation in 2003 to map and standardize their processes.

H secured ISO14000 accreditation in 1997, British Retail Consortium (BRC) accreditation in 2003 and started with 5S and CAN DO practice in late 2007. *H* had recently started focusing on Lean through 5S implementation across the shop-floor and expressed interest in applying other Lean tools like Kanban and VSM in future. In order to manage the demand schedule, *H* had implemented the Enterprise Resource Planning (ERP) system and had also integrated the element of quality management system within it to monitor information on product inspection and testing. Daily operation meetings and monthly quality meetings were organized to monitor the progress, discuss any quality related issues, and any other operational issues faced by the firm on a daily and monthly basis. It had *scrapped* the European Union best practices scheme for environmental performance (*EMAS*) in 2000, after getting started in1999, *due to the cost of certification and the time it takes to maintain the standards* (5 months).

I started its quality journey with ISO 9000:1994 certification in 1994, Investors in People (IIP) in 1998, and re-applying for the revised version of ISO, i.e. ISO 9001:2000 accreditation in 2004. The development of standard procedures, process maps and systems for ISO 9001:2000 was performed internally, rather than resorting to external consultants, to develop and retain skills for long term sustainability of the initiative. The quote from the Quality Manager further reinforces the aforementioned point – "*By doing it in-house, you learn a lot, develop skills and retain skills and are able to sustain and transfer those skills to other parts of the department. Whereas, inviting consultants to do the same job, fewer skills are retained in-house*".

J gained ISO 9000 certification in 1997, IIP in 1998, and AS 9100 quality standard for aerospace industry in 2007. The company is also accredited to SC21[1] related to aerospace industry. The documentation and standards required for ISO 9000 certification was achieved internally in the firm without any help from external consultants. ISO 9000 certification facilitated *J* in establishing systems and procedures required for AS9100 certification. The first step toward the Lean journey was implementation of 5S practice across the shop-floor in 2007. *J* applied for *EFQM*

***1* 21st century supply chains (SC21)**

This key programme is overseen by SBAC's Enterprise Excellence Board and continues the work of the Aerospace Innovation and Growth Team. SC21 aims to accelerate the competitiveness of the aerospace and defence industry. With international competition increasing, the participation of companies of all sizes throughout the UK supply chain is crucial to delivering real results from this modernisation programme.

excellence award in 2007 but withdrew the application due to the amount of time required to complete the paper work for the application. As perceived by interviewees, EFQM is not suited for SMEs as it is too bureaucratic and requires extensive commitment of time and resources for award application. *J* also *failed to implement the Kanban system* for one of their key clients in 2007 *due to poor reliability of forecast data (85% inaccurate)*. Table 7.17 summarizes the quality initiatives undertaken in the case study companies to date.

Table 7.17: History of quality initiatives in the non-Six Sigma SMEs

	F	G	H	I	J
History of quality program (QP) or certification achieved and the corresponding year	ISO 9000 (1993) ISO 9001:2000 (2003) Lean (2007)	ISO 9000 (1992) TQM (1994) ISO 9001:2000 (2003)	ISO14001 (1997) EMAS (2000) BRC (2003) 5S (2007) CAN DO (2007)	ISO 9000 (1994) IIP (1998) ISO 9001:2000 (2004)	ISO 9000 (1997) IIP (1998) AS9100 (2007) SC21 (2007) 5S (2007)
Existing QP	Lean	ISO 9001: 2000	Lean	ISO 9001: 2000	Lean

7.2.2.2. Motivation to embark on ISO 9000 and other quality initiative(s)

Interviewees were asked to comment on the statement – *'ISO 9000 acts as a building block before embarking on Lean / Six Sigma'*, to compare with the findings from survey (1st phase of study) and case studies in Six Sigma firms. Findings from these two phases strongly accentuated on having a disciplined and structured processes based on ISO standards to facilitate successful implementation of Six Sigma. Mixed reaction was observed from the participating non-Six Sigma firms on the aforementioned question.

The motivation behind achieving ISO certification in the sample firms was to improve their market share and retain existing customers. However, interviewees in all the five firms believed that accreditation also facilitated in documenting and standardizing the procedures in place. The interviewees in the five firms strongly accentuated the point of having standardized procedures in place to understand processes and measure the process performance. Viewpoints of interviewees from sample firms on ISO 9000 certification matched the opinion of interviewees from Six Sigma firms (as discussed in section 7.1.2.2).

Though *H did not applied for ISO 9000 certification*, they *followed the skeleton of ISO 9000* to establish discipline and standard working procedures for their existing processes. The work instructions and guidelines for specific job functions were attached to each machine for employees operating that machine. The quotes from the Operations Director in *H* provided more insight on the efficacy of the ISO 9000 QMS – "*I liked the aspects of ISO 9000 as an operational tool. I installed ISO 9000 but did not go for accreditation as none of our customer required ISO 9000. I wrote the manual myself, work instruction, bullet point guidelines, quality policy and procedures. We used the bones of ISO 9000 to establish standard procedures and control system in place*".

Interviewees in *I* held similar opinions to *H* regarding no need of having ISO 9000 certification if the business is in good shape. The quotes from the Quality Manager in *I* further reinforces this point- "*You do not need to have a certification to efficiently run the business. It can affect the market share if we don't have it. There isn't much advantage in having it, but there would be much disadvantage for not having it. For any company that is run moderately well, they don't need it*". The aforementioned statements from *H* and *I* imply that if a firm has well established procedures and systems and there was no pressure from external customers, one can adhere to the guidelines of ISO 9000 for maintaining the control over systems and procedures without resorting to the certification route.

Interviewees in *G* opined that it depends on the maturity of the business- whether it is a new business or already existing for years in the market. A new business would require ISO 9000 QMS to establish systems and standardized procedures documented for the company. This will set the stage for the firm to define their processes, understand the input/output, develop measurement systems and get ready for Six Sigma implementation. ISO acts as a building block for the Six Sigma initiative and it helps to take out some noise from the processes.

Interviewees in *I* also believed that the revised version of ISO 9000, i.e. ISO9001:2000 should be the starting point for any organization to embark on a CI journey. A quote from the Quality Manager in *I* reflects their viewpoint on the benefits of ISO –

"*Because ISO 9000 is a well understood basic system, we will go on to that first and build our basic system. If a business is already at a level beyond the requirement and does not have the registration, then I can see the merit of going onto the route of Lean and Six Sigma*".

Interviewees in *F*, *H,* and *J* stressed having a formalized system and procedures in place before embarking on the next stage of CI such as Lean. Interviewees in *F* and *H* stressed establishing formalized procedures before implementing Lean tools like 5S practice. Agreeing with the aforementioned point, the MD of *J* commented that – "*If the procedures are not formalized, you don't have the data, you are not doing anything in the same way. It is almost impossible to implement Lean or 5S or any kind of strategic improvement without having a solid process which is documented. When 40-50 people are working on the shop-floor, if you don't have standardized processes there would be a chaos on the shop-floor".*

The management in *F* was open to new ideas of process improvement such as Lean and Six Sigma. The company was getting support from a local government body in implementing the concept of Lean on the shop-floor. *F* had started the 5S implementation in 2007 and could visualize the dramatic improvement in shop-floor employees work efficiency. The motivation behind 5S implementation was to efficiently use the existing floor space, create a clean and tidy work environment and also reduce the cost of heating the plant. Similar reasons were cited by interviewees in *H* and *J* to implement 5S within their respective firms. It was possible to implement 5S and 'CAN DO' initiative in *H* with the generous support of their OEM, who assisted and guided a team from *H* in implementing and conducting a pilot project using the 'CAN DO' system. The reason for implementing a 'CAN DO' initiative was listed in the quotes from the Quality Manager- "*One of our key customers introduced us to the CAN DO initiative. We went to their factory and were trained on how to use the tool. We saw how the tool was working and also realized why efficiency is low in our own company. We have to run our line economically".*

Interviewees in *F* and *H* shared common viewpoints with respect to Lean implementation in their respective firms. The management in both firms decided to be leaner and more efficient in achieving set targets and outputs, be economical in production and compete globally. A brief summary of the motivation to embark on QP was presented in table 7.18.

Table 7.18: Reasons to embark on CI initiative or certification system

	F	G	H	I	J
Motivation to implement existing QP	*ISO 9001: 2000* - Improving market share - Retaining existing customer - Standardizing the procedures *Lean* - Organize the shop-floor - Cleanliness of shop-floor - Good control over inventory - Minimize the floor-space utilization	*ISO 9001:2000* - Pressure from market place - Customer led rather than company led - Holding on existing client - Preferred supplier status - Standardizing the procedures	*Lean* - Optimal floor-utilization - Promote culture of CI - Easier to implement - Quick win - Cleanliness	*ISO 9001:2000* - Externally driven by customer - Increase market share - Documented procedures - Preferred supplier status	*AS 9000* - Requirement to be supplier of aerospace industry - Increase in market share *Lean* - Control of inventory - Clean workplace - Minimize waste - Quick win

7.2.2.3. Organizational Infrastructure

In all the five firms, the ownership and responsibility for managing product and process quality was largely entrusted to the quality department. Shop-floor employees were provided with basic job-related training on maintaining systems and procedures for their own processes. Most of the job related training was provided in-house by senior /middle managers in the sample firms. Employees in the sample firms were multi-tasking, a typical characteristic observed in many SMEs. Opportunities for career progression of shop-floor employees were very limited in the sample firms. Senior Management in *F* allocated funding for professional development of the management team but the facility was not utilised due to work pressure and lack of time. There exists no formal structure in *F* to identify the training needs of the employees. Any strategic or quality related training for shop-floor employees was stopped for a year in 2006 due to sickness of the training supervisor. Both the interviewees in *F* attended a two day Lean Six Sigma Yellow Belt (YB) training program to understand the methodology and assess their readiness for Lean Six Sigma implementation. A CI team was formed recently in the production department by the interviewees to improve the process efficiency. This team led the 5S implementation with the involvement of shop- floor employees in the production department.

Employees in *G* and *I* were provided with basic training to document information for their processes and follow the written standard procedures according to the instructions provided by the internal auditor to maintain ISO 9000 certification. The management team in *G* and *I* allocated resources for educating senior/middle management team either through academic degree (such as MBA/ MSC) or routine training program (mostly in-house). Two of the senior management employees in *G* attended a YB training program to develop basic understanding of Lean Six Sigma and its efficacy in improving organizational efficiency. The knowledge from the training was not utilised to carry out CI projects due to increased work pressure and a change in management focus, as stated by interviewees.

The management team in *H* was aware of the importance of employee education and training for improving process efficiency. Any new staff go through a day induction program, are provided with specific job related training, and their knowledge is tested by middle-managers periodically. Employees were encouraged to enquire or seek feedback in case any process related issues were not clear. One of the supervisors was trained as an internal auditor to monitor that employees were adhering to documented systems and procedures for their respective processes. A process controller was appointed on a full-time basis to oversee the shop-floor productivity and maintain quality standards. Dedicated supervisors for three production lines were allocated by the management team and were empowered to take decisions related to any process or quality issues in their production line. The Operations Director attended a YB training program to facilitate CI activities within the production department. In terms of understanding the VOC or being in direct contact with the key customer, *H* had formed a business development department with three managers responsible for interacting with suppliers and customers.

The management team in *J* have trained production employees on problem solving exercises, 5S practice, adhering to principles of AS9100 and ISO 9000, and involve them in day-to- day process improvement activities. Any process improvement ideas from shop-floor employees were heard by the business development manager and their feasibility for implementation tested if appropriate. Every month a 5S audit was carried by the Operations Director to sustain the benefits gained from 5S implementation. The MD of the firm allocated resources for both on-site and off-site training of employees, e.g. half of the production employees went for a day off-site training event on AS 9100. Table 7.19 provides information on the infrastructure existing to drive the improvement across the business functions.

Table 7.19: Organizational infrastructure to support QM practices in SMEs

	F	G	H	I	J
Organizational Infrastructure	- 3 YB (external training) - Project and Quality manager responsible for product quality - Employees provided proper training whenever required	- 2 YB (external training) - Quality is the responsibility of Quality department - Employees not properly trained on ISO	- Auditor - Process Controller - 1 YB (ext. training) - Business dev. manager - 3 dedicated supervisor to monitor quality - Employees empowered to take process decision	- Quality manager respon. for product quality - Employees not properly trained on ISO	- Employees provided internal & ext. Training when required - Operations Director manages quality deptt. - Employees empowered to take process decision

7.2.2.4. Quality Tools and Techniques usage

Interviewees in the sample firms were asked about the usage of quality tools and techniques in their job for improving process and product quality. All the five non-Six Sigma firms had very limited knowledge of the tools and techniques of CI as shown in table 7.20. The reason cited for less awareness and low usage of CI tools and techniques were attributed to a lack of resources to train employees, a fire-fighting mode of operations, and a culture of subjective decision making based on gut feeling. It can be seen from the table that all five firms had no knowledge about the seven management tools and limited knowledge of OTT (no knowledge in case of *I*). Due to the recent application of Lean tools such as 5S and Kanban in *F, H*, and *J*, they were aware of the usage and usefulness of such tools for process improvement. Interviewees in the three companies were eager to learn more about OTT as they become more mature in their CI journey.

Table 7.20: Tools and techniques currently used in the non-Six Sigma SMEs

Tools & Techniques	F	G	H	I	J
Basic Tools					
Cause & Effect	×	×	×		
Check Sheet / Tally Sheet	×			×	
Control Charts	×	×	×		×
Histogram					
Pareto Charts	×	×			
Scatter Diagram					×
Process Map	×	×	×	×	×
Brainstorming	×	×	×	×	×
Management tools					
Affinity Diagrams					
Relations Diagram					
Tree Diagram					
Matrix data analysis					
Matrix diagrams					
Arrow diagram					
Process decision program chart					
Other tools & techniques (OTT)					
5S	×		×		×
Kanban	x				×
Benchmarking					
Balance Scorecard					
Statistical Process Control (SPC)					
Failure Mode and Effect Analysis (FMEA)					
Value Stream Mapping (VSM)					
Measurement System Analysis (MSA)					
Design of Experiments (DoE)					
Quality Function Deployment (QFD)					
Hypothesis Testing					
Regression Analysis	×	×			
Force Field Analysis					
Quality Costing					
Total Productive Maintenance					
Mistake Proofing					

The management in these three firms have already started allocating resources for employee training and awareness on the tools and techniques of CI. The limited knowledge of OTT gives an indication that strategic and process related decisions are based on gut feeling rather than utilising and analyzing data to make objective fact based decisions. It is imperative for the sample firms to raise their awareness of tools and techniques of CI, thus making a transition from reactive to proactive modes of operation – where decisions are based on facts and data.

7.2.3. Critical Success Factors (CSFs) and Barriers

7.2.3.1. Factors critical to success of quality program

The improvement in market share and profitability of *F* was the result of change in the management structure. The new owner of the firm was extremely talented, motivated, and had a clear long-term strategic vision of taking the business to the next level by inculcating the culture of CI within the organization. Top-down and bottom-up communication improved significantly as a result of weekly management meetings to review problems and issues or to share information. The new MD hosted quarterly business review meetings with all employees to provide updates on the performance of the firm and keep them apprised of any changes in the firm's operational strategy. At the time of interview, *F* was establishing a formal system for weekly meetings, identifying training needs of employees, forming small problem solving teams, raising employee awareness on the usage and usefulness of tools of CI, and promoting a culture of CI in the firm.

Top management in *G* had communicated the need for ISO certification to employees and considered it as the destination of their quality journey. The main focus in *G* was on regular audits that helped in keeping their quality records up to date, i.e. processes were mapped, metrics established, and data was collected for audit purposes. Training was provided to employees as and when required. A feedback system was developed to listen to employee suggestions/ ideas and use it to develop feasible solutions. The employee retention rate was very high (average 8-10 years) in *G* as there were opportunities for career progression from being a trainee to an operator to a team leader and to becoming a supervisor. Career progression, salary, reward and recognition were better compared with local industry and kept employees motivated to improve process efficiency. The process documentation and data collection strategy developed through ISO certification had helped *F* and *G* in measuring performance for some of their core business processes.

Factors identified as critical, from interviewees perspective, in the successful management of quality programs in *H* were commitment from the MD (showed commitment by attending regular monthly quality meetings; being in constant touch with heads of various departments to monitor and assess the current situation in the firm; allocate resources for training), support from the senior management team to facilitate any changes in the firm, employee empowerment, support from the middle management team, strict adherence to guidelines of ISO 9000, open to new ideas or changes for process improvement (e.g. implementation of Lean and CAN DO), education and training of employees, and networking and support received from large organizations or customers. The firm had witnessed advancement in the performance of employees after attending training programs like 5S practice and the CAN DO initiative.

The MD of *I* was very committed in maintaining and sustaining benefits gained from ISO certification. He was present in every audit meeting and would scrutinise the audit report to check employees' adherence to guidelines of ISO 9000 QMS. He was in constant communication with the senior managers related to quality, safety, health and other personal issues. The management team allocated resources for educating employees either through academic degree or routine training programs. The communication system in the firm was very efficient in reporting problems immediately to head of the site, who further reported it to the MD. Employee's grievances were analyzed on regular basis by the line manager and any serious issues identified were resolved through the intervention of the senior management team. The interviewees stressed on deploying quality systems and procedures at all levels in the organization to realise improvement in efficiency across the organization.

The CSFs for implementation of any quality programs in the firm were identified and listed by interviewees in *J*. It was believed that any change should be led and owned by the MD or senior management team in the firm. The leader should develop *the critical mass* that will lead the change and thereby develop confidence in the initiative before it is rolled out across the firm. The roll-out should begin on a pilot basis (identifying project that is simple and can be completed in a short-time period of 3-4 months) to achieve early benefit to gain organization's confidence and belief in the initiative. Employees should be empowered to monitor their own process and collect data for their processes.

The interviewees opined that SMEs had the advantage of flat organizational structure compared to large organizations that facilitated in improving top-down communication and breaking down employee resistance to change. The role of the middle manager was identified as being critical in introducing any change in the firm as they are more involved in the day to day business activities compared with the top management. A brief summary of key findings from the CSFs study in the case study firms is presented in the table 7.21.

Table 7.21: CSFs of quality programs in the non-Six Sigma firms

	F	G	H	I	J
CSFs	• Leadership • Communication • Strategic Vision • Data Collection & Measurement • Role of Middle Manager • Education & training • Networking	• Communication • Process documentation • Regular audits • Education & training • Measurement • Leadership	• Leadership • Mgmt Commitment • Education & training • Career Progression • Resources Allocations • Networking • Role of middle manager	• Intrinsic Motivation rather than externally motivated • Measurement • Company-wide involvement • Leadership • Communication	• Top Mgmt commit. • Leadership • Quick wins • Data availability & measurement • Empowerment • Education & training • Communication

The common factors cited across the five firms were: *Leadership; communication; education & training; Data collection & measurement; role of middle manager; and networking*. All the firms stressed the importance of networking with their OEMs or government bodies or academic institution to enable knowledge transfer of best-in-class practices of CI. The six common CSFs were moderately present in *F*, *H*, *J* and had a weak presence in *G* and *I*. The strong/weak presence of CSFs in the participating firms may have an impact on their organizational performance, which is investigated in section 7.2.4.

7.2.3.2. Key challenges faced in implementing quality programs

The majority of SMEs are family businesses, with the owners/ MD having limited formal business training or experiences from different business on the benefits of formalised procedures and initiatives like Lean. They prefer to have greater control over their business and tend to centralize authority to only a few senior management executives. It is practically impossible to implement any change management initiative in the SMEs without the support of owner /MD of the firm. Lack of long-term strategic vision and desire for change inhibits the success on any QP in SMEs, as viewed by the interviewees.

The MDs and the senior management teams in the *sample firms* have realised the importance of initiatives such as Lean and Six Sigma but are struggling to allocate resources and time for the same. *However, interviewees believed that resource constraints were just an excuse given by top management for not implementing any CI initiatives like Lean in the firm*. Having the right mental approach and implementing initiatives like Lean / Six Sigma would release slack resources that could be redeployed elsewhere in the firm for process improvement activities. The quotes from the Quality Manager in G further reinforces the aforementioned point – "*If the management realise the business need for Six Sigma we will surely find out the time as we have done in the past while implementing some recent certification*". Interviewees opined that employees prefer the status quo and give the excuse that these initiatives require lot of time and resources.

Findings from the usage of tools and techniques section clearly indicated limited knowledge of SMEs on tools of CI for problem solving. This may be attributed to less opportunity for education and training of employees on different CI initiatives in the SME environment. There was no culture of having data collection methodology or measurement systems in place to monitor the improvement in their processes against the existing performance metrics. There was a less structured approach in sample firms to understand and collect the VOC. The majority of the sample firms used customer complaints as a measure to address customer requirements.

F, under the leadership of a newly appointed Director in the late 1990s experienced a serious jolt in its CI journey. The MD believed in crisis management, was reluctant to allocate resources for training and development of employees, and discouraged staff who came up with new ideas for process improvement. As quoted by the Operations Manager- *"We are still suffering from the demotivation that staff developed in the period of that MD".* One of the typical barriers encountered in *F* was alienation between shop-floor employees and rest of the staff. There were separate canteens for the staff members and shop-floor employees, which further hindered the interaction and friendly communication between the two groups.

It was the lack of strong leadership, several changes in management, vision and commitment from the top that was hindering the quality improvement efforts in *G*. Interviewees in the sample firms felt that resource allocation was the biggest hindrance in driving the certification effort or implementing initiatives like Lean and Six Sigma. ISO 9000 was considered as the destination of the CI journey in the two firms, i.e. *G* and *I*. The key challenges identified in achieving and maintaining ISO certification in *I* were resistance to change from shop-floor employees, lack of resources for education and training of employees, training and awareness of the need for initiative to the rest of the employees, and persistence to stick to a reactive mode of operations. Meeting of standards should be the routine part of the way business was done and not seeing it as driven by external pressure, as was observed in *I*. Other typical barriers observed in the five firms are listed in table 7.22.

Table 7.22: Key challenges faced by NSSS to implement QP

	F	G	H	I	J
Challenges Faced by Sample firms	• People prefer to remain in Status quo • Lack of vision • Barrier between shop-floor and rest of the staff	• Change in management • Lack of management commitment • Poor training and coaching • Allocation of resources	• Allocation of resources • Networking opportunity • Role of middle managers	• Resistance to change • Training & awareness of QP • ISO as destination to quality journey • Resource availability	• Buy-in from middle managers • Resource availability • Awareness of different QP • Networking opportunity

7.2.4. Impact of Quality Initiative on Organizational Performance

Interviewees were asked for 'qualitative rating' of the benefits generated '*after*' implementation of quality programs like ISO 9000 or Lean /5S implementation, the results of which were presented in table 7.23. Interviewees from *F, H*, and *J* had realised *'some improvement'* in performance after implementation of Lean (or 5S/ Kanban in particular). On the contrary, *G* and *I* attributed their success to the application of the tools of CI and close proximity with customers rather than because of ISO 9000 certification.

Table 7.23: Hard and soft benefits realised by NSSS after implementing QP

Improvement after Six Sigma implementation	F	G	H	I	J
Hard benefits (*increase in sales, profit, productivity, market share; decrease in scrap rate, defects; on-time delivery etc*)	+	-	+	-	+
Soft benefits *(customer satisfaction, employee satisfaction, change in thinking process, proactive measures for problem solving, decisions based on data, understanding of CI initiatives, good top-down communication, etc)*	+	+	+	-	+

++ = significant improvement; + = some improvement; +- = mixed result; - = no improvement; -- = negative improvement

The improvement in organizational performance of *F* was the result of the usage of tools and techniques, implementation of ERP system, and adhering to basic concepts of Lean manufacturing, i.e. 5S practice. The implementation of 5S had resulted in soft and hard benefits being realised by the firm. 5S practice empowered shop floor employees to manage their processes, keep it clean, and continually devise ways for process improvement. This facilitated in breaking down resistance to change at the shop-floor level and inculcated a culture of CI in the organizations. This has helped to change the culture and mindset of the people. 5S implementation resulted in a significant reduction in floor space requirement to meet customer demand and thereby reducing the cost of heating the plant.

Application of Lean principles and 5S practices resulted in reduction in changeover time from 7 hours to 1 hour for one of the production lines in *H*. Other benefits observed due to the application of Lean principles in *H* was listed in table 7.24. Similar benefits were realised by *J* after 5S implementation. Regular monthly 5S audits were conducted in *J* and it was ensured that employees were implementing it in their daily job. The implementation of 5S resulted in effective utilization of floor space and employees were empowered and given ownership for improving their own processes. It had now become part of their daily practice and employees enjoy keeping their workplace clean, tidy and error-free. Low-on-time delivery performance is the major concern in *J* due to regular changes in the customer specification leading to delay in delivery of products.

Table 7.24: Benefits realised by *H* after Lean implementation

Hard Benefits	Soft Benefits
▪ Better output (from 25000 soap tablets to 45000 tablets after 5S) ▪ Less paperwork (reduced by 5%) ▪ Reduction in customer complaints by 8% ▪ Scrap rate reduced from 2% to 1.16% ▪ Savings from the project not quantified by the accountants but believed to be approximately £50000 since implementation (about 5-6 months)	▪ Lift in staff morale ▪ Staff acquainted with the usage of basic tools of CI ▪ Shop-floor empowerment to take decisions for their processes ▪ Psychological aspect of the employees has become more positive ▪ All parts of the factory are labelled and have got a location, which is strictly followed ▪ Developed a habit of data collection and measurement for all the lines on shift basis and reported back to operations manager, financial controller and quality manager on day to day basis

The improvement in performance of *G* and *I* were not attributed to ISO certification, but the use of tools and techniques of CI as cited by the interviewees. Both the companies had managed to improve customer complaints due to their close proximity with customers and the nature of their personal business. The improvement was attributed to the company's reaction to changing market forces and stiff competition. However, interviewees agreed that ISO had helped in developing process thinking, working closely with customers, and improving delivery performance. *G* does not use the metrics such as reduction of cycle time or reduction of employee complaints. Some indices used by the management board in *G* to drive the business were: *throughput per hour* or *loss time due to accident*; some other metrics like *customer complaints* were captured at middle management level to use it as a feedback to improve customer satisfaction. Some of the key changes in the performance of *G* from 2005/2006 to 2006/2007 were reported in table 7.25. There was improvement in revenue, profitability, and reduction in customer complaints observed compared to the previous year's performance in *G*. Understanding and regular follow-up of performance metrics in *I* was very poor and needed to be developed as commented by the Quality Manager. The key performance metrics used by *I* were *customer complaints, throughput, sales data, and safety performance*.

Table 7.25: KPIs used and monitored by *G*

KPIs	Actual 2005-06	Target 2006-07	Person Responsible	Key Actions Required to Achieve Target	Supporting Actions
Increase Revenue	£17.6m	£20.4m	Sales Director	Consider a customer feedback survey as a way of identifying new opportunities as well as gathering information on marketplace perception and addressing areas where improvement is required	Display KPI in each department
Increase Profit Before Tax	£724k	£905k	Managing Director	Deliver Business KPI's	Display KPI in each department. Review business KPI's with Dept Managers to ensure targets are being met. Review formally at Board and informally day to day
Delivery Performance % On Time	99.30%	98%	Operations Director	Develop a close partnership with our transport/delivery provider. Ensure clear understanding of all requirements between customer and delivery provider	Monthly performance data available and visible in each department. 1/4 Review Meetings with Delivery provider to ensure current performance is maintained and Correctible and Preventive Actions implemented
Health and Safety - Lost time Accidents	2	0	Operations Director	Fully utilise the near miss incident and accident reporting and investigation system; Health and Safety Committee - meets on a monthly basis to review the site safety management system	Incident reports and investigations available. Implement preventive and corrective action- Ongoing

On the contrary, interviewees in *F, H*, and *J* held different opinions about ISO 9000 benefits. Adherence to ISO 9000 certification in *F* resulted in establishing systems and procedures that had an impact on its performance improvement. Following the skeleton/ structure of ISO 9000 in *H* facilitated improving the quality of the product by focusing more on customer complaints, collecting and analyzing data for the complaints, and addressing the critical issues from customer perspective. This was not initially practised by employees in *H*. Comments from the MD further reinforces the importance of certification from the company's perspective – "*Personally, I think that ISO laid the foundation for us to be able to do the flow-charts; flow-charts helped us to start gathering data. Without those systems in place and owned by the people, we would have not reached the current state. ISO acts as a ready-made template to standardize the process. ISO would be a general template that can be applied to any business*".

Interviewees were also asked to rate their improvement in performance on 1-5 Likert scale against the listed criteria in table 7.26, after the implementation of QP. The scores of F, *H*, and *J* indicates that they have realised some or have made significant improvement in metrics like scrap rate, cycle time, delivery time, productivity, cost, profitability, and employee complaints. It should be noted that these three firms had just embarked on the Lean journey (*less than 7-8 months*) when the interviews were conducted in the sample firms.

Table 7.26: Impact of QP on performance of NSSS

	Performance Evaluation of companies on the 1-5 Likert scale questions				
Performance Indicators	**F**	**G**	**H**	**I**	**J**
Reduction in scrap rate	3	3	3	6	3
Reduction in cycle time	4	6	3	6	3
Reduction in delivery time	4	3	3	6	3
Increase in productivity	3	3	4	2	3
Reduction of costs	3	3	4	3	3
Increase in profitability	3	3	3	3	3
Improved sales	3	3	3	3	3
Reduction of customer complaints	3	4	4	2	3
Reduction of Employee Complaints/Grievances	3	6	3	2	3

1 = negative benefit / improvement; 2 = no benefit / improvement; 3= some benefit / improvement; 4=significant benefit / improvement; 5 =Crucial; *6 = measure not-used*

Interviewees in the three firms opined that by application of more tools and techniques of CI, they can realise significant improvement in the near future. The three firms also realised the improvement in soft factors such as customer complaints and employee complaints after implementation of Lean tools. Some of the most commonly used performance metrics in SMEs such as scrap rate, cycle time, and delivery time, were not established and used in *I*. At present, there was no culture of making decisions based on facts and data in *I*. The interviewees commented on the imminent need to establish the aforementioned metrics in the company to know how they are performing and making improvement against the established metrics. The improvement in sales, profitability and customer complaints were the result of being in frequent contact with customers and resolving their problems on an immediate basis, as commented by interviewees in *G* and *I.* ISO 9000 helped the two firms in establishing discipline in the firm but played no role in profitability improvement of the respective firms.

One of the key challenges faced by participating firms was the quantification of benefits generated from the implementation of QP. The reason cited by interviewees was lack of involvement of people from accounting and finance department as well as quality management being considered the sole responsibility of the Quality Department. Due to this reason, interviewees were unable to provide a figure for benefits realised as a result of Lean or ISO implementation in the participating firms.

A summary of key findings from the non-Six Sigma firms were presented in table 7.27.

Table 7.27: Summary of key findings from the non-Six Sigma firms

	F	G	H	I	J
Current quality program in the firm	▪ Lean *Lean program successful since its implementation in late 2007*	▪ ISO 9001:2000 *Success of the firm not attributed to ISO certification*	▪ Lean *Just started with lean implementation*	▪ ISO 9001:2000 *Follow basic guidelines of ISO for process standardisation*	▪ Lean -*A new CI initiative in the firm gaining popularity & momentum*
Motivation to implement quality program	▪ Organize the shop-floor ▪ Cleanliness of shop-floor ▪ Good control over inventory ▪ Minimize the floor-space utilization	▪ Pressure from market place ▪ Customer led rather than company led ▪ Holding on existing client ▪ Preferred supplier status ▪ Standardizing the procedures	▪ Optimal floor-utilization ▪ Promote culture of CI ▪ Easier to implement ▪ Quick win ▪ Cleanliness	▪ Externally driven by customer ▪ Increase market share ▪ Documented procedures ▪ Preferred supplier status	▪ Control of inventory ▪ Clean workplace ▪ Minimize waste ▪ Quick win
Organizational Infrastructure	▪ 3 YB (external training) ▪ Project and Quality manager responsible for product quality ▪ Employees provided proper training whenever required	▪ 2 YB (external training) ▪ Quality is the responsibility of Quality department ▪ Employees not properly trained on ISO	▪ Auditor ▪ Process Controller ▪ 1 YB (ext. training) ▪ Business dev. manager ▪ 3 dedicated supervisor to monitor quality ▪ Employees empowered to take process decision	▪ Quality manager responsible for product quality ▪ Employees not properly trained on ISO	▪ Employees provided internal & ext. Training when required ▪ Operations Director manages quality department ▪ Employees empowered to take process decision
Quality tools & techniques usage	Knowledge of and uses some basic tools of CI; No knowledge of mgmt. tool; Tools within OTT not understood & used- only uses 5S, Kanban, & Regression analysis *Awareness of OTT is going to increase as mgmt investing in employees training*	Knowledge of and uses some basic tools of CI; No knowledge of mgmt. tool; Tools within OTT not understood & used- only uses Regression analysis *Operating in fire fighting mode; less focus on process improvement activities*	Knowledge of and uses some basic tools of CI; No knowledge of mgmt. tool; Tools within OTT not understood & used- only uses 5S *Awareness of OTT is going to increase as mgmt investing in employees training*	Little knowledge and usage of basic tools; No knowledge of mgmt. tool; Tools within OTT not understood and used *More focus on increase in market share and meeting customer requirement ; less focus on process improvement*	Knowledge of and uses some basic tools of CI; No knowledge of mgmt. tool; Tools within OTT not understood & used- only uses 5S and Kanban *Awareness of OTT is going to increase as mgmt investing in employees training*
Critical Success Factors	▪ Leadership ▪ Communication ▪ Strategic Vision ▪ Data Collection & Measurement ▪ Role of Middle Manager ▪ Education & training ▪ Networking	▪ Communication ▪ Process documentation ▪ Regular audits ▪ Education & training ▪ Measurement ▪ Leadership	▪ Leadership ▪ Mgmt Commitment ▪ Education & training ▪ Career Progression ▪ Resources Allocations ▪ Networking ▪ Role of middle manager	▪ Intrinsic Motivation rather than externally motivated ▪ Measurement ▪ Company-wide involvement ▪ Leadership ▪ Communication	▪ Top Mgmt commit. ▪ Leadership ▪ Quick wins ▪ Data availability & measurement ▪ Empowerment ▪ Communication ▪ Education & training
Challenges / Barriers	▪ People prefer to remain in Status quo ▪ Lack of vision ▪ Barrier between shop-floor and rest of the staff	▪ Change in management ▪ Lack of management commitment ▪ Poor training and coaching ▪ Allocation of resources	▪ Allocation of resources ▪ Networking opportunity ▪ Role of middle managers	▪ Resistance to change ▪ Training & awareness of QP ▪ ISO as destination to quality journey ▪ Resource availability	▪ Buy-in from middle managers ▪ Resource availability ▪ Awareness of different QP ▪ Networking opportunity
Impact on Organizational Performance	**+ve impact** on *Hard & Soft* performance metrics after implementation	**No impact** – Improvement in performance metrics not attributed to ISO but other factors like close proximity to customers	**+ve impact** on *Hard & Soft* performance metrics after implementation	**No impact** - Improvement in performance metrics not attributed to ISO but other factors like close proximity to customers	**+ve impact** on *Hard & Soft* performance metrics after implementation

7.3. Findings from Practitioner interviews

7.3.1. Quality Management Practices in SMEs

In the experience of the interviewees, the majority of SMEs still believe in inspection exercises rather than having a proactive system for quality management. ISO 9000 certification was the most common accreditation system observed in the UK SMEs. As said by the interviewees, none of the SMEs in their experience had ever used assessment models such as European Foundation for Quality Management (EFQM). This result was in consensus with the findings from the literature and the first phase of study (i.e. survey). SMEs have started realising the importance of CI initiatives such as Lean and Six Sigma due to pressure from low cost South Asian economies like India and China and also due to the growing importance of the supply chain. A practitioner from Scottish Manufacturing Advisory Services (SMAS) stated that large organizations in Scotland were not pressurising SMEs to embark on Six Sigma as very few of the large firms were themselves aware of or applying Six Sigma. OEMs in Scotland look for their suppliers to have some sort of accreditation such as ISO 9000 for QMS, ISO 14000 for Environmental Management System (EMS), BRC for food & clothing industry. Within all these accreditations, the suppliers (in most cases are SMEs) were expected to meet the basic requirements of management processes or systems. As stated by the Manufacturing Institute (MI) practitioner, very few SMEs (may be 10% of the companies he has visited for conducting a diagnostic test) send out survey questionnaire to capture VOC. Data collected through customer complaints, a reactive mode of operation, was the most commonly used practise in SMEs to understand their customers' problems. However, SMEs within food, automotive and aerospace industries used questionnaire for understanding customer requirements.

7.3.1.1. SMEs perception of ISO 9000

ISO 9000 is a formal QMS and the most common accreditation among SMEs. When implemented effectively, ISO can give procedures a discipline and framework around which the company could improve their business functions. The revised version of ISO9000, which is ISO 9001: 2000, stresses continuous improvement and forces firms to frequently use quality tools and techniques such as simple bar charts, Pareto chart, and control charts. The quote from a Manufacturing Advisory Services (MAS) practitioner was in consensus with aforementioned statement- *"If you follow ISO 9000 seriously, it is beneficial. But what SMEs tend to do is they get the accreditation, they don't have resources to maintain it"*. He further stated that not all companies need ISO certification. *If you are a company that does have procedures, discipline, using effective tools, and have established business processes, you only need to have a system in place that can sustain that process.* But unfortunately many customers (larger firms) view ISO 9000 as an indicator - of culture, of stability, of a formalised approach to business processes which was viewed as a positive approach. In most cases, the customer sets a prerequisite of ISO 9000 certification for SMEs to be their supplier rather than SMEs seeing a compelling need for ISO. SMEs do implement such systems due to pressure from their larger counterparts, to increase their market share and to raise the profile of the company in the eyes of the customer.

When asked about ISO being the foundation to embark on Six Sigma, a practitioner from SMAS provided the following statement – "*I believe that a company would look at ISO 9000 before they look into Lean and Six Sigma. ISO 9000 is a good starting point for SMEs to establish systems and procedures in place, map the processes, and develop metrics for the core business processes. This would lay a good foundation to implement Six Sigma*". The practitioner from MI shared similar viewpoints on ISO being the foundation for embarking on Lean or Six Sigma.

7.3.1.2. Current status of Six Sigma implementation in SMEs

In their knowledge and experience, interviewees believed that there are very few SMEs in the UK implementing Six Sigma across their business processes. Their viewpoints were in consensus with findings from the first phase of the study. According to practitioners from SMAS and MI, many SMEs do not have enough control and stability in their processes to use Six Sigma tools & techniques, which comes later in the QM journey. They are not ready for Six Sigma implementation. These companies do not even have flow and pull-system established within their business processes. SMEs need to create the flow, implement Kanban and 5S, before embarking on the Six Sigma journey. There is a lot of low-hanging fruit that need to be attacked first by applying the Lean principles. If SMEs have achieved the first 4 Lean principles then the company may start thinking about training people on Six Sigma.

Thus, its a good idea to implement Lean to see the benefits immediately, which they will not get from Six Sigma.

As said by an interviewee from MI, *"If you visit a company and walk around their business processes - if business processes look good; people appear to be value adding; everything seems systematic with no chaos in the workplace; you can't see immediate problems on and you go on and visit their balance sheet and see whether they are making money, in such cases the company may be ready to embark on Six Sigma. No company at the moment is fully implementing Six Sigma across their entire business processes. At the most, 3-4 companies are doing some basic Six Sigma DMAIC approach and do some analysis. Most of these companies use SPC, flowcharting*".

A typical intervention by government bodies like MAS and MI starts with a 5S workshop in a SME because it is an activity that involves everyone and is easier to understand by employees - they enjoy doing it and can see direct benefits as it is very visual. After 5S, SMEs are given basic introduction to Lean principles, and then start with VSM. People understand the real value of doing 5S and VSM to identify any waste in the entire process. It was commented by the MI practitioner that many SMEs say that they do 5S in practice, but in reality have only achieved 1S or 2S. In his experience of providing services to over 250 SMEs, only 10% of companies have seriously implemented Lean.

7.3.1.3. Could Six Sigma be the solution to ailing manufacturing companies in UK?

Interviewees agreed that to survive in the global market, manufacturing SMEs in the UK need to reduce their operational cost and improve their efficiency by applying CI initiatives such as Lean and Six Sigma. The challenge for firms is to evolve in order to survive the global competition. Firms who continued to grow underwent a radical change in the way they run their business- focused more on value rather than volume; improved productivity by eliminating waste- to secure jobs, future, and maintained profitability. When companies were adhering to the aforementioned practices, Lean comes directly into the picture to achieve the objectives of eliminating waste. Some of the companies were very well developed, mature, had gone through Lean implementation, and are now thinking of implementing Six Sigma. The UK faces challenges from the Far East and Eastern European countries to match their offering of low cost products and services. To be meaner, leaner, slicker and faster than before, they have to maintain the profitability of the organization- and the way forward is to use CI initiatives such as Lean and Six Sigma.

7.3.1.4. Knowledge and usage of tools and techniques of CI

SMEs understanding and knowledge of the tools and techniques of CI were limited as stated by interviewees. Some of the most common quality tools used for process improvement in SMEs was

- *Frequency / Bar chart*
- *Pareto chart*
- *Process mapping*
- *Control charts* – many SMEs have no clear understanding of the differences between control charts and run charts; they often use run charts and have a perception that it is same as control charts. Again SMEs perceive SPC and control charts as the same, whereas there is significant difference between SPC and control charts; SPC is a technique for quality improvement which includes tools like control charts.
- 5S practice

The majority of the SMEs were not aware of the seven management tools or tools within other categories as discussed in table 7.6 and table 7.20. SMEs implementing Lean and Six Sigma are aware of the seven basic tools of CI, some management tools, and tools within other categories such as 5S, VSM, SPC, FMEA, regression analysis, to name a few. Interviewees were in consensus with the findings, presented in table 7.6 and table 7.20, on application of tools and techniques of CI within Six Sigma and non-Six Sigma firms.

7.3.2. CSFs and challenges in implementation of CI initiatives in SMEs

7.3.2.1. CSFs for implementation of CI initiatives in SMEs

Some of the CSFs identified by interviewees were listed below

- *Leadership, management involvement and commitment*: top management included CI initiatives within the strategic objectives of the business; communicated to employees the reason for implementation of Lean and Six Sigma; allocated resources and break down barriers encountered during implementation.
- *Communication:* done through shift meetings, management meetings, board meetings, whereby a company's overall performance is openly discussed, review analysed and cascaded down; other communication mediums such as intranet and newsletters are also required.
- *Existence of performance metrics* and a culture of making decisions based on facts and data; regular internal audits to see how people and processes are in conformance to standard expectation.
- *Education and training*: giving people the required skills to carry out their jobs- either technical or soft skills; education and training should be a continuous process
- *Culture of empowerment*: employees are given the authority to take decisions, and their recommendations are taken into account - they are included in project review meetings.
- *Networking*: with government bodies such as SMAS, MAS, and MI may help SMEs get the support required for implementation of CI initiatives. A practitioner from SMAS strongly accentuated changing the curricula at universities to incorporate topics such as Quality Management and Lean Six Sigma. This will ensure that graduates leaving universities will have basic knowledge of quality management topics.

The three interviewees agreed that the understanding of softer issues such as leadership, communication, culture change, education and training, empowerment, and a proactive mode of operation is more important than application of statistical tools and techniques or DMAIC methodology. In support of aforementioned statement, one of the practitioner from SMAS commented that *"the best companies I see focus on communication tools & development tools and then on the technical tools of Six Sigma and Lean".*

7.3.2.2. Challenges faced in the implementation of CI initiatives in SMEs

The interviewees listed following impediments encountered by SMEs while implementing initiatives such as Lean and Six Sigma

- *Lack of support from top management*: Many SMEs are family owned businesses, where power to bring any change lies with the CEO or MD of the firm. It is difficult to implement and sustain any change until the owner of the firm is convinced and committed to the implementation of CI initiatives
- *Lack of data availability* is a typical barrier in implementing Six Sigma in SMEs
- *Lack of awareness of CI tools & techniques*
- *Resources constraints*: especially for the smaller companies- they struggle to identify and allocate resources to improve their business processes. Government supported bodies such as *SMAS, MAS in England and Wales, the Manufacturing Institute* can play a big role in helping SMEs to implement CI initiatives. Some firms seek paid external support and advice, whereas other firms look for cost free services with less focus on the quality of external experts. In situations where the company is losing money, and/or is behind budget- any money spent on training and development is seen unnecessary that companies would rather save.
- *Culture*: no culture of continuous improvement; focus only on sales growth; working in fire fighting mode
- *Lack of education and training*: whereby they do not have an understanding of current changes required to improve quality and process efficiency

7.3.3. Performance metrics used in SMEs

From the interviewees' experience, SMEs have less established performance metrics in place compared to large organizations. It is worse in small companies, where limited KPIs exist and the focus is mainly on the *sales turnover, net and gross profit & loss, and throughput*. Medium-sized firms have more established KPIs compared to small firms. Some of the non-financial measures used in many SMEs are *customer complaints and employee turnover*. One of the practitioners commented on the usage of the following metrics in SMEs based on his past experience of implementing CI initiatives in over 250 SMEs:

- *Scrap rate*- very few firms use this metric
- *Cycle time*- Not used in many SMEs
- *Reduction in delivery time*- 20-30% of firms use this metric
- *Increase in productivity*- many firms use this metric though have not got good understanding of what productivity is
- *Reduction of cost*- Most SMEs focus on this metric to greater extent
- *Sales turnover*- Almost all SMEs use this measure
- *Customer complaints*- This is one of the common metrics apart from sales and profit used by SMEs to resolve customer issues (though it is a reactive mode of operation, where action is taken after problems have already occurred)
- *Cost of quality (COQ)*- no understanding of cost of quality concept in the majority of SMEs; for some SMEs, cost of quality means scrap and rework. It is imperative for SMEs to develop a good understanding of COQ and start measuring it to lower their cost of production and increase their sales turnover.

Interviewees also commented on the existence of the aforementioned metrics in firms implementing Six Sigma. However, understanding of COQ was still at its rudimentary stage in many Lean and Six Sigma implementing firms. *Benefits generated from Lean and Six Sigma programs in SMEs included both the hard and soft benefits.* Significant improvements in the bottom-line were observed in SMEs implementing Six Sigma and Lean through increase in productivity, sales turnover, and decrease in defects and scrap rate. Implementation of basic Lean tools such as 5S and VSM resulted in sales and profit improvement through reduction of waste and improvement in on-time delivery of products. Softer savings through Lean Six Sigma include enhanced customer satisfaction, employee satisfaction, decisions based on data, good communication systems, improvement in employee retention, to name a few.

Summary of key findings from practitioners interviews were presented in table 7.28.

Table 7.28: Summary of Key Findings from practitioner's interviews

Issues investigated	*Practitioner's Viewpoints*
QM practices in SMEs	▪ Majority of SMEs still follow inspection based quality system ▪ ISO 9000 most common accreditation system in UK SMEs ▪ EFQM assessment model not suited for SMEs ▪ SMEs realising the importance of CI initiatives like Lean & Six Sigma ▪ Reactive mode of operation- rely on customer complaints to improve product quality
SMEs perception of ISO 9000	▪ When implemented effectively, ISO can give procedures a discipline and framework ▪ The revised version of ISO, i.e. ISO 9001:2000 more effective & encourages CI ▪ There is no need of certification if your processes are disciplined and standardised ▪ In most cases, customer sets a prerequisite of ISO 9000 certification for SMEs to be their supplier ▪ ISO 9000 would lay a good foundation to embark on Lean & Six Sigma
Status of Six Sigma implementation in SMEs	▪ Very few SMEs in UK implementing Six Sigma across their business processes ▪ Control and stability of their process not enough to use Six Sigma ▪ Lean could be the starting point to get quick gains and streamline processes before implementing Six Sigma ▪ Government funded bodies like MAS, MI, SMAS role critical in facilitating SMEs to implement Lean & Six Sigma
Lean & Six Sigma solution to ailing Mfg. Industry in UK	**Yes-** to survive in global market, SMEs in UK need to reduce their operational cost and improve their efficiency by applying initiatives like Lean and Six Sigma
Knowledge of quality tools & techniques in SMEs	▪ Understanding and knowledge of quality tools & techniques very limited in SMEs ▪ Most commonly used quality tools in SMEs are bar charts, Pareto chart, process maps, control charts, and 5S. ▪ Majority of SMEs not aware of seven management tools or tools within OTT categories ▪ Six Sigma/Lean firms more aware & uses tools & techniques of quality as compared to non-Six Sigma firms.
Critical Success factors	▪ Leadership & top management commitment ▪ Employee education & training ▪ Employee empowerment ▪ Decisions based on facts & data ▪ Communication ▪ Networking
Challenges/ Barriers	▪ Lack of support from top management ▪ Lack of data ▪ Lack of awareness of tools & techniques of CI ▪ Resource constraints ▪ No culture of CI ▪ Lack of employee education & training
Performance metrics used in SMEs	▪ Less established performance metrics in place as compared to large org. ▪ Small firms focuses mainly on sales *turnover, net & gross profit/loss*, and *throughput*; Other metrics existing in SMEs are *reduction in cost, customer complaints* ▪ Limited or no understanding of important metrics like *cost of quality* ▪ Six Sigma firms have more established metrics in place as compared to non-Six Sigma firms
Impact of QP on organizational Performance	▪ ***Sig. +ve impact*** on Hard & Soft performance metrics after implementation of Lean and Six Sigma ▪ ISO 9000 had limited influence on improving organizational performance

7.4. Differences between SMEs and Large organization

Interviewees from the 10 participating firms and 3 government bodies were asked to comment on the differences in SMEs and large organizations that may facilitate or hinder the implementation of CI initiatives in the firm. Responses were in consensus with findings from the literature. Some of the key differences between SMEs and larger organizations as cited by the interviewees were:

- SMEs have the advantage of a flat organizational structure that promotes faster top-down and bottom-up communication with minimal distortion of messages issued to the employees. This flat structure also promotes greater visibility across the firm to raise staff awareness of changes happening in the business
- Shorter communication channels means that there are fewer people to convince, which can make management's job easier and faster
- It is easier to introduce any change management / process improvement activities in the firm if the senior management is committed to allocate resources for the change. Senior management is closer to those working on the shop floor-the type of influence that senior management can bring to the shop floor will be quicker.
- Decision making is easier in SMEs compared to large organizations as the power resides with the owner of the firm in most cases
- Compared to larger organizations, SMEs face resource constraints to invest in new technology, invest in employee education and training or recruit skilled manpower
- SMEs are less aware of opportunities to network with other similar/different businesses, government bodies or academic institutions. They have minimal knowledge of the support rendered by government organizations such as the MAS in England, Scotland, Wales and Ireland or the MI

When interviewees in the case study firms were asked to comment on the *relationship between the size of an organization and Six Sigma implementation*, the majority believed that such programs were challenging to implement within a SME environment. The MD of *A* opined that - *"it is easier for bigger companies to implement it. To some extent it is true. But we are a small company and we have done it and our success has been because management is very committed to it. But I think if we had* *not got the grant in the early days, I am not sure that we would have gone such a long way in that everybody was trained on YB and two other belts*".

Interviewees in *B* stressed understanding the culture of the organization, irrespective of the size of the organization, to successfully implement such a system. Accentuating the importance of culture, the Lean Champion in *B* stated the following – "*I think you have got to address culture massively, irrespective of the type and the size of the organization. If we don't understand the culture of the business and how to make a transition, any initiative will fail. For SMEs, you have got deadlines to meet and work in fire fighting mode. Anything you try and plan is difficult, which causes frustration*". Interviewees in *E* stated that Six Sigma implementation is dependent on the complexity of the process, and repetitive processes existing in the company. It has got no relation to the size of a company.

The same question was posed to the three practitioners from SMAS, MI, and MAS. The interviewees felt that size does matter for implementation of Six Sigma but that does not preclude SMEs from embarking on the CI journey of Lean and Six Sigma. Large organizations have structured and dedicated resources and culture of CI that facilitates ongoing quality improvement projects. For SMEs, it varies incredibly depending whether it is a small or medium-sized firm. As stated by one of the practitioners, "*there are small companies that are doing well that are utterly down to leadership style, knowledge, commitment, attitude, behaviour of individuals. Some small business are incredibly successful and adaptive to new ideas and systems. I am working with a company with 16 employees with 3 BB, 1 MBB*".

Interviewees were introduced to the growth models of small businesses, such as stage models from Greiner (1972, 1998) or Churchill and Lewis (1983), and the state model from Phelps *et* al (2007), and were asked to comment on whether a good understanding of the characteristics of each stage/state in growth models may help the firm to decide their readiness for implementing CI initiatives such as Lean and Six Sigma. For more information on the growth models, refer to Chapter 2. Interviewees had a common consensus that positioning of the firm in the growth stage model and implementation of CI initiatives may vary from one business to another. It may be that a firm is still at stage one or stage two of the growth model (stage1 and stage 2 typically represents a firm struggling for survival and working in a reactive mode) but implementing Lean successfully. It also depends on whether SMEs want to grow their business or maintain the status quo so that the owner had complete control over the entire operation. The MD of *J* further reinforces the aforementioned point – "*Understanding the characteristics of SMEs at each stage of growth-, It is a good model for a company to know where they are; however many SMEs prefer to maintain the status quo and does not want to grow*". Interviewees reacted positively towards the state model proposed by Phelps *et al* (2007) and were in consensus with the researcher that external intervention in a SME environment is a must for the acquisition of external knowledge, to develop the ability to recognize value of new information, assimilate it, and apply it to commercial ends to allow their business to grow. The inclusion of factors such as operations improvement, formal systems, people management, and strategy in the model made it a more relevant and practical model for firms embarking on the CI journey to follow. Interviewees were in agreement that understanding of the characteristics of the growth model would certainly help owners and senior managers to reflect on their current practices and its impact on the growth of the firm. It would be difficult to decide on implementation of a CI program depending upon their positioning on the growth model.

7.5. Six Sigma Readiness Index

This section attempts to identify the factors that constitute Six Sigma Readiness Index (SSRI). The literature review on CI maturity model (refer to Section 3.7.2) facilitated in understanding the characteristics of firms at different stages of CI journey. The author made a similar attempt to identify the characteristics of organization that are ready to embark on Six Sigma journey by proposing a SSRI. This section includes discussion on how the factors, to include within SSRI, were identified by interviewing delegates from the five Six Sigma firms, three practitioners from government bodies, and getting opinion from 30 delegates attending International Conference on Six Sigma in Edinburgh (15^{th}-16^{th} December, 2008). The interviewees were asked to cite five most important factors that should be present in the company before embarking on the Six Sigma journey. The five non-Six Sigma firms were not asked this question because of their lack of knowledge or experience in implementing Six Sigma. Table 7.29 summarises the key factors listed by participating firms to check an organizational readiness for Six Sigma implementation. As some factors were falling in the similar category, e.g. employee education and training, employee empowerment were both related to people issues or human resource management, it was rational to group them together. The factors listed in table 7.29 were grouped in five categories as follows:

- *Style of Leadership within the company*- whether ready for the challenge and will support the change; whether the culture of the company will support the focus on implementation of CI or whether it will fade away as a another fad of the month; management focus, drive and commitment is a must for the success of any change program.
- *Communication to all relevant staff*- a well established top-down and bottom-up communication channel is required; communication through shift meetings, management meetings, board meetings, whereby company's overall performance is openly discussed, review analysed and cascaded down. Different media sources such as intranet, newsletters, management address to all employee on any major change, and notice boards should be in place for effective communication.
- *Established Systems and Procedures*- the company should have established systems and procedures in place by strictly adhering to quality management systems standards or Lean implementation; all core and support processes should be identified and mapped; key performance metrics for core processes should be established and data available and recorded in a systematic manner; knowledge and usage of basic tools of CI in daily jobs.
- *Resources and skills to facilitate implementation*- one of the most important requirement is to build your human capital by providing education and training for employees; collaborating with government bodies or local universities for developing understanding of CI initiatives.
- *Cultural Change*- giving empowerment to employees to take decisions for their processes; proactive approach to manage operations and processes; absence of blame culture; decisions based on fact and data.

Table 7.29: Summary of readiness factors listed by participating firms

Readiness Factors for Six Sigma implementation	*A*	*B*	*C*	*D*	*E*	*3P**
Strong Leadership	x	x	x		x	
Top Management Commitment	x		x	x		x
Commitment from middle managers & shop floor employees		x		x		
Everybody involved in CI initiative in the firm			x	x	x	x
Employee education and training	x				x	x
Employee empowerment		x				
Sound quality management system in place		x		x		
Good data collection methodology in place	x		x	x		x
Cross-functional team			x		x	
Established communication system	x	x			x	x

**3P- Three practitioners from government bodies*

The same question was posed to delegates attending the 3rd International Conference on Six Sigma in Edinburgh on 15th -16th December 2008. Thirty delegates attending the workshop on 'Six Sigma for SMEs', delivered by the author and his Director of Studies, were asked to rank the top six out of ten CSFs (identified from the first two phases of the doctoral study), using an electronic voting pad, that they considered important and should be present in any organizations before they embark on the Six Sigma journey. The results of the voting were presented in figure 7.2.

The delegates voted for the following factors that may be incorporated in the Six Sigma Readiness Index that could test an organization's preparedness for Six Sigma: leadership & management commitment (36%); communication (12%); education & training (10%); data collection & performance measurement (9%); employee's empowerment (8%) and customer focus (8%). The findings from the table 7.29 and figure 7.2 would be used in Chapter 9 to design and construct Six Sigma Readiness Index. The next section summarises the key findings from this chapter.

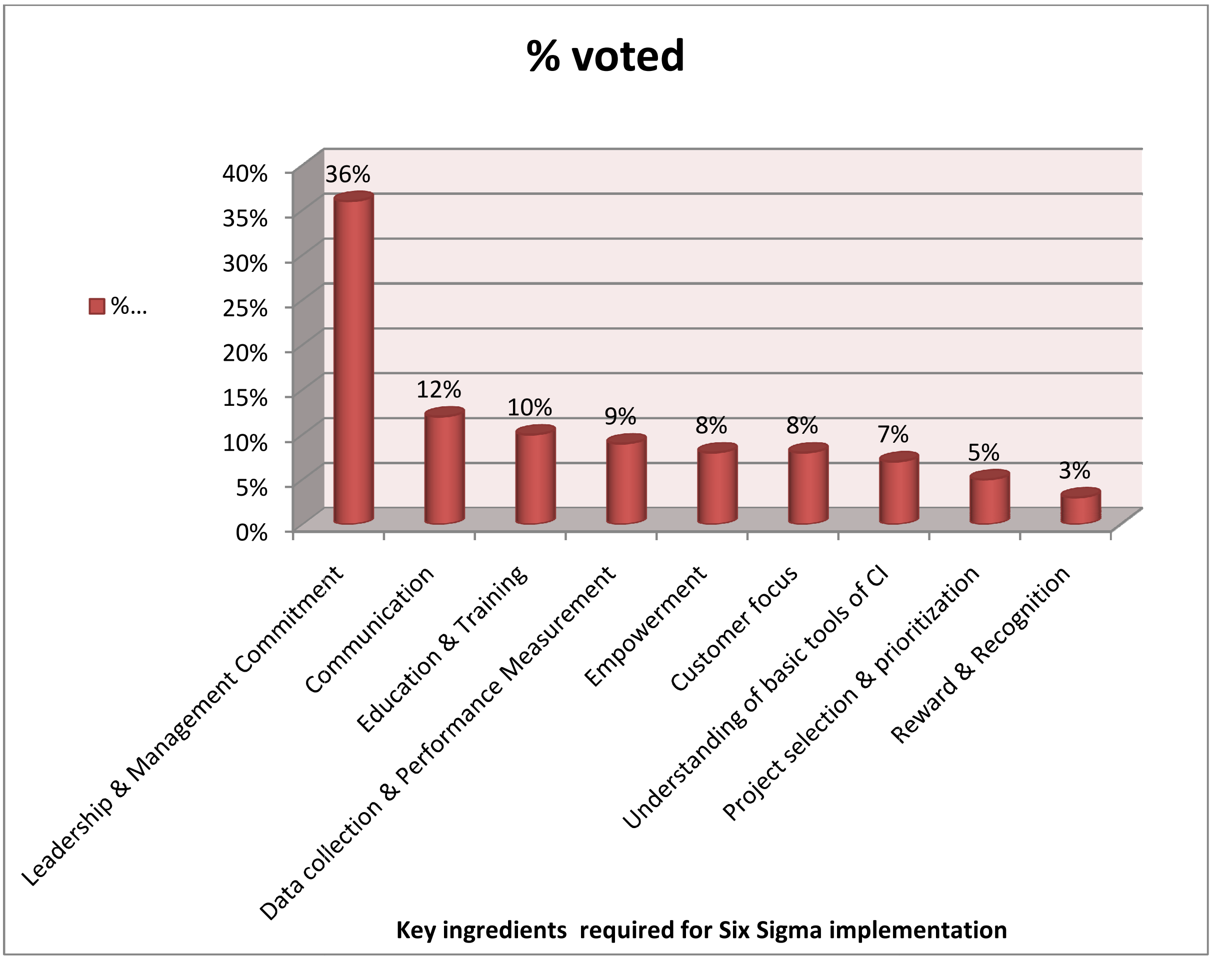

Figure 7.2: Six Sigma readiness factor voted by conference delegates

7.6. Summary

The findings from case study analysis clearly demonstrate that Six Sigma can be implemented successfully in any organization, irrespective of the size of the company. Company *A* with 36 employees has managed to implement Six Sigma in its production processes and have reaped significant benefits since its implementation. Participants commented on the differences in the characteristics of SMEs compared with large organizations and negated the existence of links between growth models of SMEs and implementation of CI initiatives in SMEs. The findings from the first phase of research matched with the case study findings in terms of quality management practices, CSFs and barriers, and performance measurement in the Six Sigma and the non-Six Sigma SMEs. Six Sigma SMEs have not followed any framework for implementation but accentuated the need for a customized framework tailored to the needs of SMEs.

The interviewees in the sample firms agreed that a good foundation of QMS based on ISO 9000 principles may facilitate implementation of Lean and Six Sigma in SMEs. SMEs expressed their interest in networking with academic institutions or government bodies to know more about the funding opportunities or help they can get in improving their business performance through implementation of Six Sigma. Some of the SSS were aware of government funding schemes such as knowledge transfer partnership (KTP), though majority of the SMEs had no clue on how to get government funding or academic support.

The qualitative data analysis of ten case study firms identified several *'critical incidents'* that either facilitated the firm in the implementation of quality initiative(s) or led to the failure of those quality initiative(s). Understanding of critical incidents may help an organization to increase their chance of success when implementing any new CI initiative(s) within their business processes. The critical incidents captured through interview process in the ten participating firms were listed in table 7.30.

Table 7.30: Critical incidents during implementation of quality initiative(s) in SMEs

Case Study firms	Critical Incidents
A	▪ First attempt to implement Lean failed due to lack of training and employee involvement at shop-floor level ▪ Secured a partial funding from government body that helped them to implement Six Sigma ▪ The MD committed resources for next 5 years to deploy Six Sigma across the firm ▪ Use of train the trainer approach and rotation of team members in Six Sigma project to develop a sustainable organizational infrastructure ▪ Formation of cross-functional team for Lean / Six Sigma project ▪ Top-down and bottom-up communication channel established ▪ Involvement of finance director to quantify the savings generated from Six Sigma projects (The FD was not previously involved in cost-benefit analysis at the start of project)
B	▪ Failed to successfully implement TOC and TQM due to lack of training and employee involvement at shop-floor level, and involvement of project leader in day to day jobs ▪ Initial Six Sigma training was partially supported by their OEM ▪ The MD attended GB training and executed a GB project to demonstrate long-term commitment in Six Sigma; this also helped in breaking down resistance to change ▪ Formation of cross-functional team for Lean / Six Sigma project ▪ Top-down and bottom-up communication channel established
C	▪ Six Sigma initiative funded by their Parent Company and also supported by government bodies like SMAS ▪ First attempt to implement Lean failed due to lack of training and employee involvement at shop-floor level; Also initial Six Sigma training was only provided to process Engineer and rest of the staff were alienated to attend the awareness training ▪ Hoshin Kanri approach failed due to lack management involvement & commitment

D	▪ Six Sigma and Lean Initiative failed in the firm due to change in management structure and shift in management focus ▪ The new MD of the parent company more focussed on achieving the production target and allocated minimal resources for staff training on CI initiatives like Six Sigma ▪ Six Sigma and Lean initiative became fragmented after Lean Champion moved to a different company ▪ Struggled to find leader to lead the change
E	▪ Six Sigma initiative funded by their Parent Company ▪ Facing challenge to identify Six Sigma project in a job-shop production environment ▪ Formation of cross-functional team for CI project
F	▪ Support from SMAS to get started with Lean ▪ Appointment of new MD, who believed and supported CI initiative in the company ▪ Staff still suffering from the demotivation developed in the period of previous MD, who was negative about CI initiatives ▪ Alienation between shop-floor employees and middle manager by having separate canteen for two groups
G	▪ TQM initiative failed as it was led by one person, who left the company in 1994 ▪ Quality responsibility of quality department and thus knowledge of quality management limited to 2-3 person in organization ▪ ISO 9000 considered as destination to quality journey by top management
H	▪ Support from OEM to train on CAN DO and 5S practice ▪ Employee empowerment by middle manager to improve individual process ▪ Followed the skeleton of ISO 9000, without going for certification, for process standardization
I	▪ ISO 9000 standards were developed and established in-house without resorting to any external consultant ▪ ISO 9000 considered as destination to quality journey by top management
J	▪ Committed MD allocated resources for staff training ▪ Regular monthly audit on 5S to sustain benefits gained from its implementation ▪ Withdrew application for EFQM excellence award due to amount of time required to complete the application ▪ Kanban system failed due to poor reliability of forecast data

The key findings from the CSFs and barriers to implementation section were matched with the literature in Chapter 8 and 9 to design the customized Six Sigma framework for SMEs. The next chapter includes discussion on cross-case analysis and the results were matched against the findings from the first phase of research and the literature review.

Chapter 8
Discussion of Key Findings

8.0. Introduction

Chapter 6 and Chapter 7 presented the results from a survey and multiple case studies in SMEs on their status of Six Sigma implementation. Two clusters of Six Sigma and non-Six Sigma firms were formed for conducting quantitative and qualitative analysis (within case analysis of each cluster). This chapter discusses the findings from the *cross-case analysis* across two clusters followed by mapping the findings against the survey results and the literature. Cross-case analysis facilitated in understanding the evolving patterns across the four research questions listed below:

RQ1: *What makes SMEs different from large organizations?*

RQ2: *What are the critical differences in quality management practices of Six Sigma and non-Six Sigma SMEs?*

RQ3: *What are the critical success factors and barriers to implementation of Six Sigma in SMEs?*

RQ4: *Does the performance of Six Sigma firms differ from non-Six Sigma firms?*

Retrospectively, the literature review findings on the aforementioned questions were compared and contrasted with the findings from the empirical research. The key findings from the literature and RQs were combined to address the fifth RQ on Six Sigma Readiness Index in Chapter 9. The critical differences between the Six Sigma SMEs (SSS) and the non-Six Sigma SMEs (NSSS) as identified from case study analysis were reported below.

8.1. SMEs vs. Large Organizations

Interviewees in the 10 case study firms held a common consensus on differences in characteristics of SMEs compared with their larger counterparts. SMEs were said to have advantages in their flat structure, faster communication, greater top-down visibility, and faster decision making process compared to larger firms. Due to the flat structure of SMEs, the owner/ manager had the understanding of operational issues, processes, customer needs, and were more involved with the customers, e.g. *A, B, C,* and *J*. The decision making power was vested in 3-4 members of senior management team that included the owner or the MD of the firm. Middle managers in the small firms like *A*, *E, and J* were responsible for managing more than one departmental function simultaneously due to limited resources. For example, the Operations Director in *A* also acted as HR Manager to identify the training needs of employees. Strategic activities in some firms like *D, I,* and *J* were informal, intuitive, invisible, and often owed more to a speedy response than to in-depth analysis, matching with findings from literature (Barnes, 2002; Sum *et al*., 2004; Beaver and Prince, 2004). The empirical research clearly identified availability of resources required to bring any change as the biggest challenge in SMEs compared to large organizations that may hinder or jeopardize their motivation to embark on the CI journey. The findings from the literature were in consensus with the case study results on differences in characteristics of SMEs and large organizations (Greiner, 1972, 1998; Churchill and Lewis, 1983; Phelps *et* al., 2007; Ghobadian and Gallear, 1996, 1997; Mitra and Pingali, 1999; Noci and Toletti, 1998; Yusof and Aspinwall, 2000 a, b; McAdam, 2000; Youssef *et* al., 2002; Garengo *et* al., 2005a,b; Barringer *et* al.,2005; Deros *et* al., 2006; Kumar, 2007; Antony *et* al., 2005, 2008).

The case study analysis clearly indicated that SMEs were less aware of opportunities to network with other similar/different businesses, government bodies or academic institutions. They have minimal knowledge of the support rendered by government organizations such as the MAS in England, Scotland, Wales and Ireland or the MI. Networking with academic universities may facilitate knowledge transfer and enhancement of existing capabilities within the SME (North et *al*., 2001; Thomas, 2007). Phelps *et al* (2007) accentuated the role of interventions, internally or externally, for firms to raise their absorptive capacity and ascend from a state of ignorance to a state of implementation with respect to factors such as operations improvement and people management. Local universities play a key role in disseminating latest technical knowledge to small firms through collaborative programs such as the Knowledge Transfer Partnerships (KTP), SEEKIT, and SCORE to name a few. KTP programs between academic institution and industry is an effective vehicle for enabling the introduction and application of CI initiatives within

SMEs. However, very few SMEs (less than 2%) are acquainted with such schemes (North et *al*., 2001; Thomas, 2007). Knowledge of schemes like KTP may alleviate SMEs concerns and dependability on external consultants for enhancing their process performance.

A common opinion was held by interviewees in the 10 sample firms that the size of the organization does not hinder Six Sigma implementation. Though they struggle to allocate resources for implementing such programs, the benefit outweighs the initial investment made at the start of program. This was the common opinion shared by interviewees across the Six Sigma cluster. Interviewees opined that knowledge of growth models proposed for SMEs in the literature may be beneficial for SME managers to understand their positioning on different stages of models against the established criteria for each model. This may further help them to understand the requirement to move to the next stage in the growth model and whether their existing capability and working culture will enable to make that transition possible. However, they said that it would be difficult to decide on the implementation of a CI program, e.g. making a transition from ISO certification to Lean/ Six Sigma implementation, depending upon their positioning on the growth model. Similar findings were observed during the literature review process. Stage models proposed in the past have received criticism in recent years for being conceptual, descriptive (Phelps *et al*, 2007; Bessant *et al*., 2005), speculatively normative (Gibb and Davies, 1990), and prescriptive in assuming that all firms grow through a series of predictable phases or preordained stages.

8.2. Quality Management Practices in SMEs

In the SMEs literature, the most common reason cited for not embarking on continuous improvement (CI) initiatives like TQM, Lean or Six Sigma was the availability of resources, commitment from the top management to invest in the required resources for successful implementation, and considering ISO certification as a destination to CI efforts (Ghobadian and Gallear, 1996; Wiele and Brown, 1998; Yusof and Aspinwall, 1999; Terziovski and Samson, 2000; Witcher, 1994; Terziovski *et al*., 1997; Davig *et al*., 2003; Antony *et al*., 2005, 2008; Kumar, 2007; Thomas *et al*., 2009). This study further enriches the literature by providing in-depth information on the reasons for not implementing Six Sigma.

Findings from the first two phases of this doctoral research indicated that very few SMEs in the UK are aware of Six Sigma and those implementing Six Sigma have less than 3-5 years of implementation experience. The common reasons cited in this empirical research for non-implementation of Six Sigma was lack of awareness of the system, not sure if relevant, availability of resources to implement Six Sigma, never heard, and ISO considered as destination to CI journey. Antony *et* al (2005, 2008) pilot study on Six Sigma in the UK SMEs also reported the low awareness and implementation of the Six Sigma initiative in the participating firms. Thus, the exemplar of best-in-class quality management practices is still evolving in such firms. Even the NSSS have realised the importance of initiatives like Lean/Six Sigma and have started investing resources to avail themselves of the benefits derived from the implementation of such initiatives.

The empirical findings also indicated that SMEs are not implementing EFQM model as they perceived the model was suitable only for large organizations. The model was bureaucratic and time consuming, making it difficult for SMEs to allocate scarce resources for its implementation and follow-up. The literature also reported limited evidence of success of self-assessment models (e.g. EFQM, AQA. MBNQA) in a SME environment as these models were bureaucratic, time consuming, required excessive paperwork, and increased complexity for managers (Watts and Dale, 1999; Wilkes and Dale, 1998; Hewitt, 1997; Thomas and Webb, 2003). According to the author, majority of SMEs are at their inception stage of CI journey, where processes are not standardised, performance metrics are not established, SMEs have limited knowledge on the usage of CI tools and techniques, to name a few. EFQM is an assessment model that is effective for organizations that have an established track record of commitment to CI and compete for EFQM excellence award. It may take few years or a decade for SMEs to reach the standard where they can think of qualifying for EFQM excellence award. However, this is not the case for every SME. *A* and *B* are the two firms in the case study sample that rigorously followed the principles of CI and may qualify for EFQM excellence award. It could be the case that application of EFQM model in SMEs may grow in popularity in the next five to ten years, when SMEs have more established QMS, performance metrics, and decisions based on facts and data.

The SSS selected their most talented people across the organization to train on Six Sigma and execute projects forming a cross-functional team. *To develop the bench-strength* for continued sustainability of the Six Sigma program, the team members were rotated back to their original job after project completion and new members were included in the cross-functional team to execute the Six Sigma project. This policy compensated for their scarce human resources as well as facilitated in developing Six Sigma knowledge team across the organization. The practice of rotation policy compensated for the scarce resource problem faced by SMEs. *This strategy of rotation policy was not explicitly mentioned in the literature.* On the contrary, process/ quality improvement was the responsibility of quality department to a greater extent in the NSSS. Employees were working in fire-fighting mode in such firms with more focus on targets and deadlines to meet rather than improving the quality of product and services delivered to its customer (Ghobadian and Gallear, 1996, 1997; Yusof and Aspinwall, 2000b; Antony *et al*., 2005). Employees in SSS (except company *D*) were empowered to take decisions for improving their processes. A blame and fear culture presence was minimal in the participating SSS. The decision making power in the NSSS was entrusted to middle-level managers or supervisors.

Six Sigma should not be introduced when a company is going through a restructuring process, e.g. merger, change in management, and downsizing. It was also suggested that if a company is planning for redundancy of employees, it should be done before the introduction of any change program. Otherwise if employees are made redundant after implementation of initiatives like Six Sigma, it will leave a poor image in the eyes of the employees leading to greater resistance to change.

The SSS were more conversant with the usage/benefits of basic tools of CI, management tools, and tools within OTT category compared to the NSSS, where knowledge of tools and techniques of CI was very limited. Though, the knowledge and usage of tools and techniques of CI was better in the SSS compared to the NSSS, they still are far behind in using tools within OTT category compared to many large organizations. The state of knowledge and usage of tools and techniques of CI in the case study firms is depicted in the figure 8.1 and figure 8.2. Similar findings were observed in the literature when comparing the tools and techniques usage of TQM firms against non-TQM firms (Yusof and Aspinwall, 2000 a, b, c; Ghobadian, 1996, 1997; Spencer and Loomba, 2001; Davig *et* al., 2003; Sousa *et al*., 2005, 2006;

Thomas *et al*., 2009). Basic tools of quality such as process maps, graphs, check sheets, and Pareto charts were reported as the most commonly used tools in SMEs. SMEs struggled to use complex tools and techniques of CI such as SPC, DoE, and FMEA to name a few. Ahmed and Hassan (2002) also revealed that tools and techniques application are more prevalent in TQM SMEs compared to non-TQM SMEs.

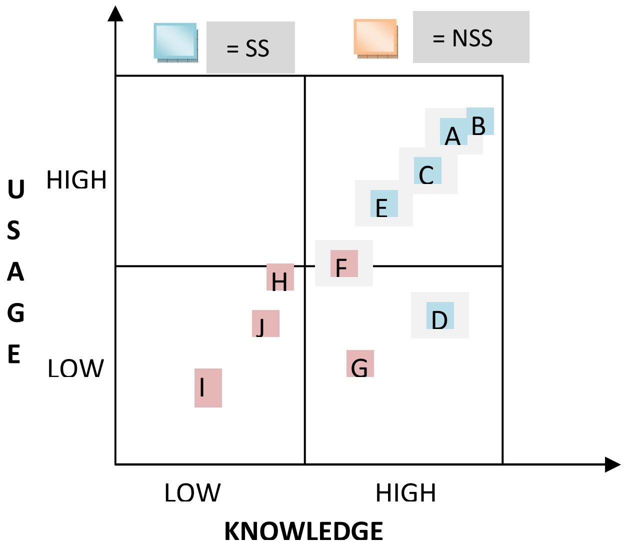

Figure 8.1: Usage of basic tools

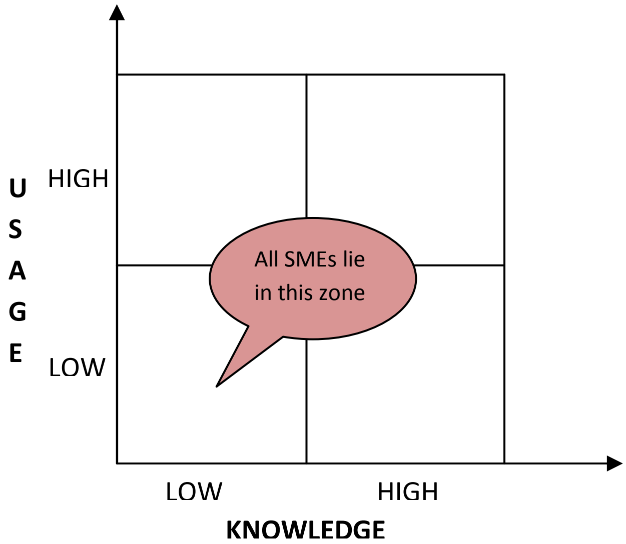

Figure 8.2: Usage of tools within OTT category

The literature also revealed that management in small firms lack theoretical knowledge on the application of statistical tools to resolve problems and fear of statistics was restraining them from embracing tools and techniques that can have significant affect on SMEs performance (Thomas *et al*., 2009; Sousa *et al*., 2005, 2006; Spencer and Loomba, 2001; Davig *et al*., 2003).

In spite of the critical differences between the SSS and the NSSS, interviewees and practitioners held a common viewpoint on the role of the ISO 9000 in establishing formal procedures and systems before embarking on Lean or Six Sigma. The findings from this study gave an indication, similar to findings from the literature (Gotzamani, 2004; Gotzamani and Tsiotras, 2002; Soltani and Lai, 2007; Taormina, 2002; Terziovski *et al*., 1997; Taylor, 1995; Russell, 2000; Coleman and Douglas, 2003; Kanji, 1998), that ISO (or any system that establishes procedures and discipline in the workplace) may be the foundation or building block to embark on the Lean / Six Sigma journey. Interviewees believed that if a firm already had established system, procedures, and data collection strategies in place, *they do not need ISO certification but can follow the guiding principles* that may aid the implementation of Six Sigma. The literature also indicated a similar trend - If a company had religiously followed the basic principle of ISO 9000 and developed procedures as prescribed in the standard, there was no need for certification [provided there is no pressure from key customers](McTeer and Dale, 1996). Stated by Yusof and Aspinwall (2000b) and supported by the findings of this study – "*Companies do not have to attain ISO 9000 certification if they fully understand the true nature of a good quality assurance system*". Findings from the first two phases and the literature also indicated the use of Lean for the first round of improvement and quick wins in SMEs (Achanga *et al*., 2006). This will facilitate in breaking down employee resistance to change. Based on aforementioned findings, the author is also proposing to use QMS for process standardizations, followed by Lean implementation before embarking on the Six Sigma journey, as shown in figure 8.3. However, this proposition should be treated cautiously and tested in further research.

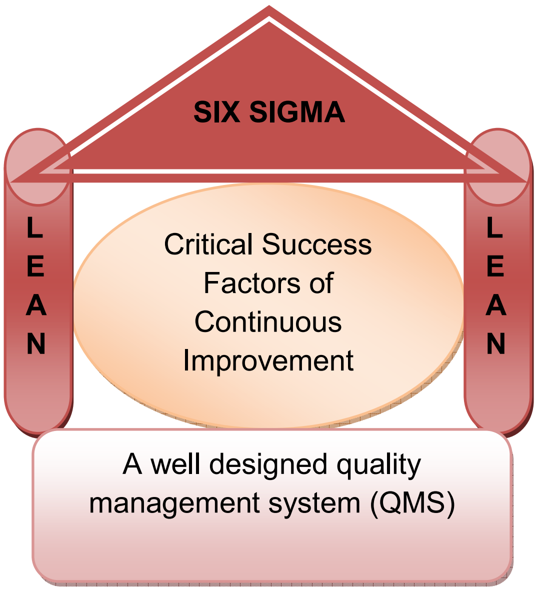

Figure 8.3: The role of QMS and Lean to facilitate Six Sigma implementation in SMEs

It was emphasized that it is necessary to understand the history of quality initiatives in the company before embarking on any change program. Knowledge of success or failure of past initiatives will have an effect on the success of any new initiative introduced in the company. Moreover, it will help to understand the role of leadership and culture of the company by reviewing its quality history of the company. Leadership and senior management commitment is paramount for the success of any CI initiatives (Yusof and Aspinwall, 1999; Antony *et al*., 2005; Kumar, 2007).

SMEs expressed interest in networking/ collaboration with academic institutions or government bodies to know more about funding opportunities or for help in improving their business performance through implementation of Six Sigma. Some of the SSS were aware of government funding schemes through bodies such as MI, SMAS, and MAS, though the majority of SMEs had little idea of how to obtain government funding or academic support. *No specific framework or model was followed in the participating firms to facilitate Six Sigma implementation*. Six Sigma was rolled out in firms with the help of government funding, or OEM support, or pressure from the parent company. However, firms agreed to the fact that a guiding principle in the form of a framework may facilitate implementation of Six Sigma and sustain its benefit on a long-term basis. The most frequent reason cited in the literature for the failure of business improvement methodology was the wrong implementation approach (Deros *et al*., 2006). This was the reason why many researchers have emphasized the need to design structured framework for problem solving (Davies and Kochhar, 2000; Goh and Ridgway, 1994). Some the reasons why an implementation framework is needed are:

- It provides a focus on the objective to be achieved and links the change management initiative to business objectives (Davies and Kochhar, 2000)
- It minimizes fire fighting and provides a guideline or structure that is easy to understand, efficient, and can be implemented at reasonable cost and time (Deros *et al*., 2006; Davies and Kochhar, 2000)
- It forces the management to address a substantial list of key issues which otherwise might not be addressed (Aalbregtse *et al*., 1991)
- It also provides an avenue for managers who are interested and enthusiastic in quality improvement to provide essential leadership for the change initiative agenda (Arya and Callaly, 2005)
- It facilitates the unification of several disciplines in the change process (Mathaisel, 2005)

There are limited models / frameworks in quality management literature proposed for TQM/ Lean/ Six Sigma implementation in SMEs compared to large organizations. Even some of the existing quality frameworks/models on SMEs ignored the discussion on how SMEs with their limited resources can opertionalize the frameworks/models. The literature and empirical findings strongly support the need to design a customized framework tailored to the needs of SMEs to ensure successful implementation and sustainability of the initiative (Ghobadian and Gallear, 1997; Wilkes and Dale, 1998; Yusof and Aspinwall, 2000c; Tannock *et al*., 2002). The author proposes a customized Six Sigma framework for SMEs (discussed in Chapter 9) based on the findings from empirical research and grounded in literature.

8.3. Critical Success factors and Barriers

Common opinion was shared by the SSS and the NSSS with regards to listing of factors critical to the success of CI initiatives or certification systems. Strong leadership, management commitment, communication, education and training, measurement and data collection, and customer focus were considered critical in driving any change within SMEs. Strong Leadership and management commitment was considered as the most important factor to drive CI efforts in a SME environment as all the powers are vested in the hands of MD/owner of the firm. If they are convinced of the benefits of initiatives like Six Sigma (as observed in company *A and B*), it is much easier to break down any stumbling blocks or resistance to change by employees. The greater presence of these attributes in firms, irrespective of the type of initiatives in firms, was driving the positive change in their quality management practices.

Similar findings were reported from the first phase of the study. The mean score of the SSS and the NSSS across the 13 CSFs were very similar and statistically insignificant. It was further deduced that these CSFs are equally important for firms implementing any type of change management program such as Six Sigma, Lean, or certification system such as ISO 9000. However, when it comes to application of these CSFs within the firms, statistically significant results were observed in the sample firms. At this juncture, it may be fair to say that those firms applying the CSFs within their day to day job had a better quality culture than firms struggling to implement the

CSFs. Table 8.1 was constructed to compare the application of CSFs in the SSS and NSSS, as identified from case study findings. Though networking was cited among the seven most important factors by the firms, in practice they are all struggling to develop collaboration with their OEMs or Government bodies or Universities. The strong presence of CSFs in SMEs may have a direct impact on the performance of firms, though it needs to be statistically validated in further study.

Table 8.1: Application of CSFs identified from case study analysis

CSFs applied in the Firms	**Six Sigma Firms**					**Non-Six Sigma Firm**				
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**
Strong Leadership	++	++	++	--	+	++	-	+	+	++
Education & training	+	++	++	-	+	+	-	+	-	+
Employee's empowerment	++	+	+	-	+	-	--	+	+	+
Communication	++	++	+	+	+	+	-	+	-	++
Customer focus	++	++	+	+	+	+	-	+	-	+
Networking	+	+	+	-	-	-	-	-	-	-
Data collection & measurement	+	+	+	-	+	-	-	+	-	+

++ = Strong; + = Adequate; - = weak; -- = Missing

Practitioners' viewpoints also matched with the findings from a survey and multiple case studies. The literature review had also identified the aforementioned factors as critical to the implementation of CI initiatives. (Shea and Gobeli, 1995; Parkin and Parkin, 1996; Ghobadian and Gallear, 1996, 1997; Yusof and Aspinwall, 1999; Rahman, 2001; Lee, 1998, 2004; Lin, 1999; Wessel and Burcher, 2004; Antony *et al*., 2005, 2008; Kumar, 2007; Achanga *et al*., 2006).

Two new CSFs emerged from the interview processes that were least cited in QM literature, namely networking and the role of middle managers. As cited in Section 8.1, networking was one of the weakest areas of SMEs compared to large organizations. They were less aware of any networking or funding opportunities available through government funded bodies or academic institutions (North et *al*., 2001; Thomas, 2007). The participating case study firms expressed desire to expand their networking capability that may have facilitated the firms to embark and sustain benefits from Six

Sigma implementation. The role of middle managers in leading and supporting the change was also identified as critical to the success of CI initiatives in SMEs. This factor was identified by the author while conducting a pilot case study on Six Sigma implementation in a SME (Kumar, 2007).

It was interesting to observe that CSFs identified from empirical research on Six Sigma in SMEs matched with the CSFs proposed for the growth of small businesses in Chapter 2 ((Mitra and Pingali, 1999; Shim *et al.*, 2000; Barringer *et al.*, 2005; Phelps *et al.*, 2007; Ostgaard and Birley, 1994; Barbosa and Fuller, 2007; Mazzarol, 2007; Chen and Huang, 2004). Factors such as leadership, management style, customer focus, systems and procedures, human resource management, and networking were cited both in empirical research and literature on the small business growth. It gives an indication that firms that are growing and which possess the aforementioned factors are ready to embark on the CI journey of Lean or Six Sigma. Thus, the knowledge of state model proposed by Phelps *et al* (2007) may facilitate SMEs to judge their positioning on the model and thereby take decisions for external intervention to acquire knowledge on CI initiatives such as Six Sigma.

Scarcity of resources was cited as the most common impeding factor in making the change happen across the sample firms followed by middle-managers role, commitment from senior management team, change in management structure, and poor training and coaching. However, interviewees and practitioners viewed scarcity of resources as an excuse by top management for not implementing or dedicating resources to the CI effort in the firm. The benefits realised by Companies *A, B, and C* after implementation of Six Sigma had surpassed the investment made at the initial stages of implementation. The literature review process also identified similar barriers to the implementation of CI initiatives in SMEs, namely: resource constraint, lack of senior management commitment, lack of education and training of employees, lack of understanding of CI program, to name a few (Moreno-Luzon, 1993; Lee and Oakes, 1995; Haksever, 1996; Parkin and Parkin, 1996; Ghobadian and Gallear, 1996, 1997; Yusof and Aspinwall, 1999; Lee, 2004; Antony *et al.*, 2005, 2008; Kumar, 2007).

The survey result does not cite top management commitment as one of the top five impeding factors, whereas case study findings indicated lack of senior management commitment as one of the barriers to embark on a CI journey. It is difficult in a SME to get started with any change management initiative or sustain the efforts without the commitment from the top management, as was observed in company *D, G*, and *I.* Company D struggled to sustain the initial benefits realised from Six Sigma implementation due to change in management structure and focus of senior management team.

It is imperative for SMEs to have a strong management commitment and good leadership skills before embarking on the Six Sigma programme. If Six Sigma is only considered as the implementation of statistical tools and techniques to solve complex problems in the organization, it is doomed to fail due to its very weak linkage to strategic business objectives. Six Sigma is about overall business strategy, culture and change, and small companies embarking on the Six Sigma initiative need to build all of this into a sound corporate strategy plan (Antony, 2008b; Kumar *et al*., 2008).

8.4. Impact on Organizational Performance

The existence of metrics for core business processes and decisions based on fact were the key features in the SSS compared to the NSSS, though such metrics are still evolving in the SSS. Significant differences in performance were observed during case analysis of the SSS and the NSSS. The SSS performance in operational metrics [such as scrap rate, cycle time, on-time delivery, and yield] and strategic metrics [such as sales, profit, customer satisfaction] outweighed those achieved by the NSSS. Each Six Sigma project was linked to bottom-line savings, though initially SSS struggled to quantify the benefits realised from implementation of the program. Recent involvement of executives from the accounting and finance department to carry out cost-benefit analysis of Six Sigma projects had resolved the issue of hard-dollar quantification from Six Sigma projects. No such steps were taken in the NSSS.

The empirical findings also indicated that Six Sigma metrics like COPQ was still an unexplored area in a SME environment. The definitions of quality-related costs are in fairly specious terms in SMEs. As said by Dale *et al* (2007), COPQ constitutes between 5-25% of the company’s annual sales turnover or operating costs. Though this figure was established in researching large organizations, but still if SMEs are losing 10-15% of their sales due to COPQ it would be difficult for them to remain competitive in the global environment. Moreover, they cannot afford to lose money as they already have resource constraints.

The overall benefits realised by firms after implementation of CI initiatives or certification systems was plotted in figure 8.4. The classification of four categories in figure 8.4 is explained as follows: *Stars* are firms applying QP across the business and reaping significant benefits from implementation (e.g. reduction in rework & scrap, increase in productivity, profit, sales, customer satisfaction, etc); *Promising Starters* have applied QP to some of its processes and have realised significant benefits from implementation; *Strugglers* are those firms that have applied QP across the business with little benefits; and *Looser* are firms that had little or no benefit from implementation of QP (Rungasamy *et al.*,2002).

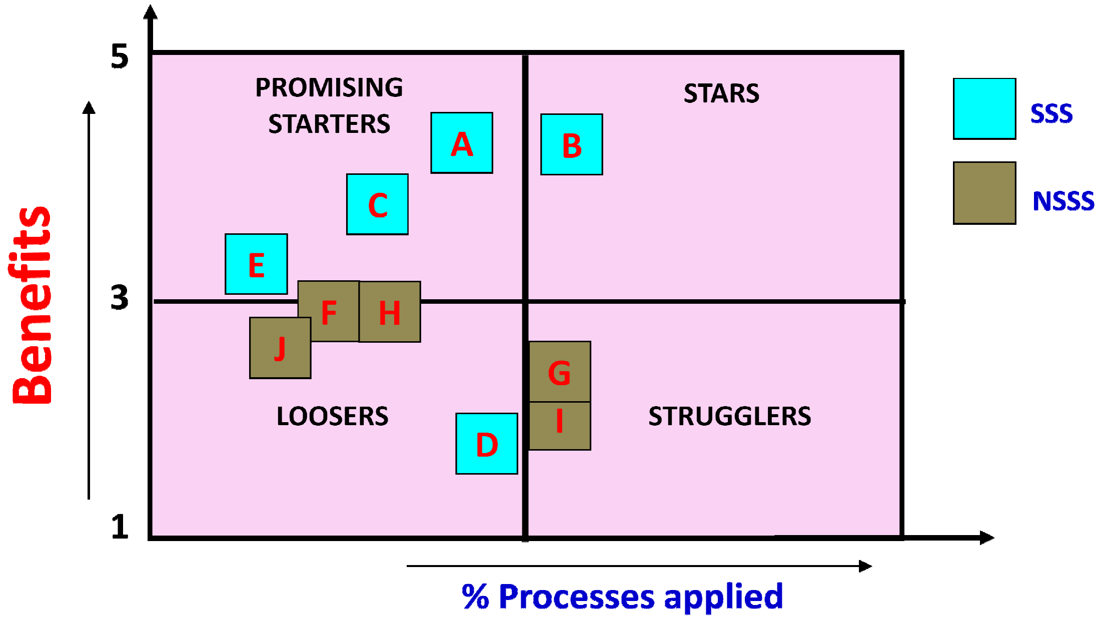

Figure 8.4: Overall benefits from implementation of quality program in SMEs
Adapted from Rungasamy et al (2002)

It can be seen from figure 8.4 that *A* and *B* are the exemplar firms, reaping significant benefits from Six Sigma implementation. Though *F, H*, and *J* lies on the border of *'loser'* and *'promising starter'* classification, they have realised some benefits from implementation of Lean and are committed to their adherence to the CI journey. The three firms have recently started implementing Lean (less than 1 year experience of Lean implementation at the time of interview). On the contrary, *D*, *G*, and *I* are struggling to realise benefit from implementation of quality programs due to change in management commitment and focus on other business priorities.

In the NSSS category, SMEs (company *F, H*, and *J*) realised some improvement in the hard and soft metrics (listed in table 7.23) after implementation of Lean. The visual tools and techniques of Lean (5S and Kanban) were easily understood by shop-floor employees and were being used to improve their process performance. Involvement of shop-floor employees during Lean implementation facilitated in breaking down any resistance to change, lifted staff morale, the psychological aspect of employees became more positive, and helped to promote the culture of CI. Common opinion was voiced in the SSS and the NSSS to use Lean for the first round of improvements and quick gains before embarking on the Six Sigma journey. Both the SSS and the NSSS have realised quick and visible benefits from the Lean implementation.

The benefits realised in the 5 NSSS were not the result of ISO 9000 certification, as commented by the interviewees. The improvement was achieved through their close proximity with key customers and addressing their concerns on an immediate basis. The findings from the survey were very similar to results obtained from case study analysis. The NSSS in the first phase mostly included SMEs having ISO 9000 certification. Significant statistical differences were observed in performance improvement of firms after implementation of Six Sigma compared to post implementation of other quality initiatives/ certification system in SMEs.

The literature in the past was devoid of any research comparing the performance of Six Sigma and non-Six Sigma SMEs. Researchers have focused on measuring and comparing the performance of TQM SMEs against non-TQM SMEs. TQM SMEs outperformed non-TQM SMEs with regards to established performance metrics used by the firms (Lee, 2004; Sousa *et al*., 2005, 2006; Beheshti and Lollar, 2003; Jones *et al*, 2005; Prajogo and Brown, 2006; Sohail and Hoong, 2003). Mixed results were observed on the contribution of ISO 9000 in improving firms performance (Ahire *et al*., 1996; Tsiotras and Gotzamani, 1995; McAdam and McKeown, 1999; Gotzamani, 2004; Gotzamani and Tsiotras, 2002; Sohail and Hoong, 2003; Rahman, 2001a; Taylor and Wright, 2003). For example, Sohail and Hoong (2003) observed a positive impact of TQM on performance of ISO certified firms as compared to non-certified firms. On the contrary, Rahman (2001a) and Taylor and Wright (2003) study revealed no difference in the performance of firms with and without certification.

The practitioner interviews also indicated improvement in bottom-line results as observed in Lean/Six Sigma SMEs through increase in productivity, decrease in scrap rate and rework. Increase in customer satisfaction, employee satisfaction, fact based decision making, and enhanced employee retention rate were typical softer savings realised in Lean Six Sigma SMEs. The financial measures were reported as the widely used metrics in comparison to soft factors in SMEs to monitor organizational performance. This finding was in consensus with the literature (Sousa *et al*., 2005, 2006; Davig *et* al., 2003; Lee, 2004; Lewis *et al*., 2006).

8.5. Summary

The author in this doctoral research demystifies the myth – Six Sigma works only in large organizations, by investigating into application of Six Sigma in the UK SMEs and presenting the benefits realised by SMEs from successful implementation of Six Sigma. No doubt deploying Six Sigma will cost organization some money and time, but it will be worth expending time, money and effort to achieve real measurable financial results. Organizations face myriad of problems in their day to day functions. Six Sigma can be applied where there is a problem, irrespective of type or size of business (Brue, 2006). Six Sigma can act as a catalyst for changing SMEs in the quest for business excellence by mobilising their intellectual capital, provided there is total commitment.

This chapter critically analyzed the key findings from the empirical research with the results reported from the literature review process. The discussion was based on the four research questions established in Chapter 1. The flat structure of SMEs promote faster decision making, faster communication, and greater top-down visibility that makes implementation of CI easier in SMEs compared to large organizations. It was reported from empirical research that it was difficult to decide upon the implementation of CI initiatives based on the firm position on the growth models proposed for small businesses. The quality management practices in the SSS were more established and prevalent as compared to the NSSS. Based on empirical findings and literature comparison, ISO 9000 or a similar QMS system was proposed to be the foundation for Six Sigma implementation. However, such propositions need to be statistically validated in further study. Strong leadership and management commitment were identified as the most important CSFs for implementing any change in organizations. Networking and role of middle managers were identified as two new CSFs from this study which had limited citation in the quality management literature on SMEs. All the SMEs faced the challenge of limited resources to implement initiatives like Lean and Six Sigma. The need for a Six Sigma framework for SMEs was accentuated in the empirical research as well as supported by the literature.

The critical differences between SSS and NSSS as identified from cross- case study analysis were reported below.

- Six Sigma firms were more conversant with the usage of basic and advanced tools of CI for problem solving compared to NSSS, where knowledge of tools of CI was very limited.
- SSS selected their best talented people across the organization to train on Six Sigma and execute projects by forming a cross-functional team. Process improvement was the responsibility of quality department in NSSS.
- Strong leadership, management commitment, communication, education and training, measurement and data collection, and customer focus were considered critical in driving any change within SMEs. These attributes were driving the positive change in the SSS, which was missing or had limited presence in NSSS
- Each Six Sigma project was linked to the bottom-line savings. Also people from the finance department were involved to carry out the cost-benefit analysis before embarking on any Six Sigma project. No such steps were taken in NSSS.
- SSS performance in operational metrics [such as scrap rate, cycle time, on-time delivery, and yield] and strategic metrics [such as sales, profit, customer satisfaction] outweighed those achieved by NSSS.
- Existence of metrics for core business processes and decisions based on fact were the key features in SSS.

The details of construction of the readiness index and development of the Six Sigma framework were provided in the next chapter, i.e. Chapter 9. The index and framework were developed by comparing the findings from the empirical research against the literature.

Chapter 9
Readiness Index and Implementation Framework

9. 0. Introduction

The research investigated and critically reviewed literature on quality management framework proposed for SMEs (Chapter 3, Section 3.7.3.2) and the framework used by case study SMEs in this empirical research to embark on the quality journey (Chapter 7, Section 7.1.2.1). The findings from the literature review and empirical research were used to develop a Six Sigma Readiness Index and a customized Six Sigma framework for SMEs. The factors included within the index and the framework had emerged from the survey and multiple-case studies conducted within SMEs and mapping the findings against the literature. It is imperative for a SME to first assess their preparedness for Six Sigma before embarking on this journey as they cannot afford to lose any money because of wrong implementation decisions or strategies used. SMEs passing the readiness test can embark on the Six Sigma program by strictly following the framework proposed in this chapter. The index assessed an organization’s preparedness for Six Sigma implementation and the framework proposed may facilitate organizations to implement Six Sigma successfully and sustain the benefits realised from the initiative on a long-term basis. The next section presents the Six Sigma Readiness Index for SMEs that was tested in three organizations for validity followed by the introduction to customized Six Sigma framework for SMEs.

9.1. Six Sigma Readiness Index

9.1.1. Introduction to Six Sigma Readiness Index

Parasuraman (2000) proposed Technology Readiness Index (TRI), to understand customer readiness to use a new technology-based system, which refers to “*people’s propensity to embrace and use new technologies for accomplishing goals in home life and at work*”. In order to introduce the principles of concurrent engineering in the construction industry, Khalfan et al (2001) developed a readiness assessment model to investigate the extent of organizational readiness to embrace concurrent engineering and to identify the risk involved in its implementation within the company.

Oakland and Tanner (2007) comment on the importance of assessing the readiness for change – "*The experiences of many organizations that have launched change programs such as Six Sigma, is that the first part- readiness- is not at all well understood or developed*". The readiness index identifies the criteria that should be in place before Six Sigma implementation begins; the framework incorporates criteria that would ensure the successful implementation of Six Sigma and sustain the momentum, and benefit realised over longer period. Taking cue from the aforementioned research, the author defines Six Sigma Readiness Index (SSRI) for SMEs as ***'the extent of SMEs preparedness for the introduction of Six Sigma. It is also a way of assessing the degree to which the organization's present values are congruent with the values needed in a Six Sigma organization'***. The purpose of the index was to assess the level of quality management practices observed in the past within an organization while implementing initiatives like TQM, Lean or ISO. Assessment of a firm's preparedness for Six Sigma was only possible by reflecting on their past quality management practices, e.g. leadership commitment/people management / process management to name a few, and measuring the success /failure of those initiatives with respect to the factors listed above. The measurement and monitoring of criteria would facilitate smoother implementation (without disruption) of Six Sigma across the organization.

9.1.2. Criteria to measure the Six Sigma Readiness Index

The answer to the RQ5 on SSRI was developed by understanding the characteristics of SMEs, Six Sigma, and maturity models and comparing the findings from empirical research with the literature. The interviewees in the SSS were only asked (NSSS were not asked due to their lack of experience in implementing Six Sigma) to cite the key ingredients required by SMEs as a prerequisite to embark on the Six Sigma journey. The factors identified (from case studies) as necessary to be present in a firm to facilitate smoother implementation of Six Sigma were – leadership style, communication, established systems and procedures, resources and skills, and culture change. The Readiness factors identified from voting of delegates in a Six

Sigma conference were: leadership and management commitment, communication, education and training, data collection and performance measurement, employee empowerment, and customer focus.

It was imperative at this stage to compare the findings of empirical research with the existing CI maturity models to identify the commonalities and differences in key factors and their variables included in the existing models. The most common factors appearing across the three quality awards (MBNQA, EQA, and AQA) were *leadership, people management, process management, and customer focus / satisfaction* (Davies *et al*., 1996; Wiele and Brown, 1999; Wiele *et al*., 1996; Ritchie and Dale, 2000; Ghobadian and Woo, 1996). Nonetheless, it was argued that such quality awards were not suited for firms beginning with the TQM journey (Yusof and Aspinwall, 2000a; Hansson and Klefsjo, 2003). The applicability of such models within SMEs context was also questionable (Thomas and Webb, 2003; Wilkes and Dale, 1998; Watts and Dale, 1999; Hewitt, 1997).

The review of the most popular CI maturity models gave information on the journey of an organization to excellence in different stages and how they can build an organizational culture based on the facets of TQM (Kaye and Dyason, 1995; Lascelles and Dale, 1991; Dale and Lascelles, 1997; Dale and Smith, 1997; Dale *et al*., 1997; Bessant and Caffyn, 1997; Bessant *et al*., 2001). Typical characteristics exhibited by firms at level 4 in Dale and Lascelles (1997) and level 5 in Dale and Smith (1997) included emergence of leadership culture with few champions to lead TQM implementation (TQM accepted by all employees); long-term companywide education and training program; cross-functional team leading process improvement across organizations; organizational culture based on trust, reward and recognition, and employee involvement; proactive quality management system; and benchmarking data used to facilitate improvement activities. The characteristics of organizations were similar to era three of the Kaye and Dyason (1995) model or level 3 of the Bessant *et al* (2001) model.

Firms meeting the requirement of era four of the Kaye and Dyason (1995) model were way ahead in their CI journey to excellence. This may be the ideal condition for firms to implement Six Sigma, where quality is integrated within the business plan, employees are empowered to take decisions, business results are reviewed against objectives, and use of customer feedback to formulate the firm's strategy and its impact on society was also evaluated. Even achieving at least the characteristics of era 3 in the Kaye and Dyason (1995) model or level 4 in the Dale and Lascelles (1997) or level 5 in the Dale and Smith (1997) or level 3 in the Bessant *et al* (2001) model, which is not very common in many SMEs, may facilitate the firm in the implementation of Six Sigma (though this is not guaranteed if the leaders have no desire to move to the next era). These characteristics indicate organizational readiness to embark on initiatives like Six Sigma, as it matches the characteristics of Six Sigma, as evidenced in the literature (Chapter 3, section 3.2).

The readiness factors identified through interviews and voting in Section 7.5 were compared with the literature to construct the Six Sigma Readiness Index (SSRI). The five most common factors cited by empirical research and literature review of CI maturity models were- Leadership; Customer Focus; Measurement and Process; System and Control; and People Management. The key variables stated within the aforementioned stages of the CI maturity model were included within the five factors of the readiness index. The variables included within each factor are presented in table 9.1 and a detailed questionnaire on Readiness Index was attached in the Appendix IV. *Established criteria for the SSRI aim to measure the organizational practices in the past to ascertain their status on the CI journey and understand the role played by leadership teams in driving the CI activities across the organizations.*

- *Leadership* – included discussion on the CEO/MD involvement in the past in leading CI initiatives across the organization; including CI within the strategic objectives of the business; communicating the organization's vision and mission statement vertically down the organization; allocating resources and breaking down stumbling blocks to facilitate implementation; recognition and reward of employees involved in successful CI projects
- *Customer Focus* – includes variables such as an organization's commitment in meeting customer expectations; giving customers priority over internal policies; and understanding value-added activities from the customer perspective
- *Measurement and process* – decisions based on facts and data; all key processes documented; existence of internal and external performance measures; understanding of basic tools of CI. A well-defined objective and

quantified metrics established to measure the outcome from an intervention is a prerequisite for successful change (Oakland and Tanner, 2006, 2007; Shia and Saad, 2008). Any CI process is based on the basic foundations of data and information (Yusof and Aspinwall, 2000a). The established metrics, tied to the business bottom-line, will help in monitoring the change (before and after outcome) in the process from an intervention such as Lean or Six Sigma.

- *Systems and Control* – prevention based system; problem-solving infrastructure in place; proactive quality management system; ISO or Lean as a foundation to have established procedures and non-value added activities identified; effective communication system; cross-functional team
- *People Management* – training and development needs of employees identified; employees accountable for their processes; discouragement of blame culture; involvement of all employees in CI activities

Table 9.1: The key constituents of Six Sigma Readiness Index

Criteria/ Precepts to measure Readiness Index
Leadership
L1- Visible involvement and continued commitment in leading companywide quality initiatives in the past (e.g. being available to speak to staff, operating an ‘open door’ policy, walk the floor, holding briefing and feedback meetings)
L2- Understands and supported continuous improvement (CI) in the past by provision of appropriate resources, assistance, and breaking down stumbling blocks
L3- Effectively communicated vision and mission, long-term quality goals and objectives vertically down the organization to achieve quality excellence
L4- CI within the top business priority and strategically linked to business goals
L5- Recognised and appreciated the efforts and success of individuals and teams
Measurement and Processes
M1- All major business processes identified and documented (using flowcharts or process mapping techniques)
M2- Key internal and external performance measures identified, defined, and developed
M3- Basic tools of CI understood and used by employees for problem solving
M4- Operations and decisions based on fact and data
M5- Performance indicators monitored, displayed and communicated through debriefing sessions, intranet, and bulletin boards on a continuous basis
People Management
P1- Employee’s knowledge and competencies linked to training & development strategies, and career progression identified, developed, and sustained
P2- Employees respected accountability and discouraged blame culture
P3- Employees feel free to report information on errors and defect
P4- Organization promoted the involvement of all its employees in quality and CI
Systems & Control
S1- A policy deployment and problem-solving infrastructure in place together with robust and proactive

quality system
S2- A high degree of closed loop error prevention through the control of basic production/ operation and/or service processes
S3- Effective communication system and timely information flow vertically and horizontally at all levels
S4- Standardised procedures in a documented quality management system (religiously follow the principles of ISO 9000; certification not required until asked by customer; or identified value added activities through lean implementation)
S5- Cross-functional team established as a way of working and to take decisions on system-wide problems
Customer Focus
C1- Organization regularly seeks customer feedback to understand the key causes of concern, main complaints, and expected performance from customers
C2- Customer focus and satisfaction given priority over internal policies
C3- Understanding of value-added and non-value added activities from customer perspective

Findings from survey and case studies suggested having a good quality management system or implementing Lean for quick gains before embarking on Six Sigma. Lean tools such as 5S and VSM are very simple, easy to understand, and give empowerment to employees to improve their own processes. The feeling of empowerment along with the quick benefits realised from application of these tools minimizes employee resistance to change and thereby facilitate progression towards Six Sigma implementation. *It is not a strict rule that Lean or ISO should be applied first before embarking on Six Sigma. It depends on the type of problems organizations are facing. However, the literature and empirical findings suggest that standardisation of work processes / Lean implementation build a culture of CI that aid Six Sigma implementation.* This point was included within the 'Systems and Control' factor of the Readiness Index.

It is imperative at this point to understand the differences between the key ingredients (KI) of Readiness Index and Critical Success Factors (CSFs) of Six Sigma. *The five factors included within the Readiness Index assess organizational preparedness to implement Six Sigma based on their past success or failure in implementation of quality initiatives / quality management practices*. These KIs must be present in a SME to consider successful and effective implementation of Six Sigma. The higher score for the five factors may ensure readiness of an organization to implement Six Sigma and experience a smooth cultural transition during the change process. Whereas, CSFs represent the essential ingredients without which a Six Sigma project stands little chance of success (Antony & Banuelas, 2002). *CSFs evaluate an organization commitment to Six Sigma during or after the implementation of the initiative*. The higher score for CSFs may have a direct impact on the strategic and operational performance metrics of an organization, giving an indication of successful deployment of Six Sigma across the business function.

9.1.3. Scoring criteria for the Six Sigma Readiness Index

Based on the findings from multiple-case studies, it was suggested that any organization going through restructuring, merger and acquisition, or change in leadership and management should not embark on Six Sigma as it would not be a right time for the firm due to their unstable organizational structure. These criteria were included in the start of the readiness questionnaire (refer to Appendix IV for more information). All criteria were assigned equal weight in evaluating the Readiness Index score. A score is calculated for each variable within each factor on the 0-4 Likert scale, with 0 being '*percept not implemented at all*'; 1 implies '*percept slightly implemented*'; 2 indicates '*percept moderately implemented*'; a score of 3 indicates '*good implementation of percept*'; and 4 being '*percept fully implemented*'.

A score of 3 or above for each factor indicates that an organization's culture is ready to embrace Six Sigma. This threshold value was determined after several brainstorming sessions between the author and participating SMEs in this study, viewpoints of Six Sigma practitioners, and mapping and matching the readiness variables across the existing maturity models of TQM or CI. As discussed in section 8.5, achieving at least the characteristics of era 3 in the Kaye and Dyason (1995) model or level 4 in the Dale and Lascelles (1997) or level 5 in the Dale and Smith (1997) or level 3 in the Bessant *et al* (2001) model, which is not very common in many SMEs, may facilitate the firm in the implementation of Six Sigma (though this is not guaranteed if the leadership have no desire to move to the next era).

These characteristics indicate organizational readiness to embark on initiatives like Six Sigma, as it matches with key ingredients required to start implementation of Six Sigma, as evidenced in the literature. A score of 3 in the readiness assessment exercise is indicative of achieving the aforementioned stages/era/level of different maturity models and a readiness to embark on their next CI journey, i.e. Six Sigma. If any organization is scoring below 2 for each criterion, they need to identify the area of weaknesses for further improvement to get ready for Six Sigma implementation. SMEs should get their basic understanding of CI right before embarking on Six Sigma. A score between 2-3 requires careful investigation across five factors of the Readiness Index before implementing Six Sigma. In such circumstances, SMEs are advised to observe the score for the 'leadership' factor and if it is closer to 3 or equal to 3, than they may think of going ahead with the implementation. Leadership emerged as the most important factor for the success of any CI initiatives, as evidenced in the literature, as good leaders make things change or happen in organizations. A higher score for leadership compared to the other four factors may help SMEs to improve on other factors as they have commitment from their top management. Thus, a score of 3 is indicative of a 'green signal', i.e. go ahead with implementation; a score between 2-3 is an 'amber signal', i.e. be cautious and carefully investigate five factors before implementation; and a score less than 2 is a 'red signal', i.e. SME not ready for Six Sigma implementation. A SME scoring 3 or above may be branded as *'qualifier'* (ready for Six Sigma implementation); a SME having a readiness score between 2-3 may be classified as *'vigilant'* (careful scrutiny required before implementation); and any firms scoring less than 2 are not ready for the Six Sigma journey and thus classified as *'struggler'*.

The results from the readiness exercise will facilitate the identification of strengths or opportunities for improvement in the CI efforts of an organization and help them to:

- Understand the cultural readiness to implement Six Sigma from a strategic to an operational level;
- Understand the level of commitment to CI initiatives demonstrated by leader / CEO/ MD in the past; and
- Identify areas for improvement in an organization through the readiness exercise

The Readiness Index was tested for its robustness and validity in three SMEs (who participated in the 2nd phase of study, i.e. case study), the results of which are presented in the next section.

9.2. Evaluating SMEs Readiness for Six Sigma

In order to test the efficacy of the Readiness Index in truly capturing the information it was designed for, three SMEs from the second phase of the study agreed to participate in this validation exercise as well as test their readiness for Six Sigma implementation. It was intended initially to select a Six Sigma implementing SME and a non-Six Sigma firm to test the validity of index. A firm that had realised bottom-line benefits and enhanced customer satisfaction from implementing Six Sigma should score higher than 3 for most variables within the index. Also, any firm implementing ISO 9000 or Lean and interested to embark on Six Sigma journey should have an overall score closer to 3. Keeping these two sampling criteria in mind, *Company A* and *F* were shortlisted (after their consent to participate in the study) for readiness exercise. *Company D* was struggling to keep Six Sigma initiative afresh and alive due to a change in the management structure and focus of the company. They also approached the author to participate in the readiness exercise and identify their weaknesses or gaps in their CI efforts.

The readiness index is still in its testing phase and may be revised in future based on the comments of participating firms and Six Sigma experts. The demographic details of the participating firms were provided in table 9.2. For more information about the company, please refer to Chapter 7 on case study analysis (three firms listed as *A*, *D*, and *F* in chapter 7 were included in this readiness exercise).

Table 9.2: Demographic details of firms participating in Readiness exercise

Company	Manufacturing Activity	Company Type	Location	Quality Initiative	Number of employees
A	Electronics & Semi-conductor	Independent	England	Lean, Six Sigma	36
D	Mechanical	Part of MNC	Scotland	Lean, Six Sigma	105
F	Electrical	Independent	Scotland	ISO 9000, Lean	86

Two members (at middle management level) from each firm were requested to fill in the readiness questionnaire after reaching a common consensus to rate each question on 0-4 scale within the survey. It was not possible to collect data from senior management teams or shop-floor employees due to time and resource constraints. Future work will focus on a full blown readiness survey across the companies to assess their readiness for Six Sigma implementation.

The score for 5 factors of the Readiness Index for *A, D* and *F* was presented in table 9.3. *These scores were interpreted based on the responses of middle managers to the questionnaire and linking it to the findings from the case study conducted (in the second phase of the doctoral research) within the three firms*. It can be observed from the table that *A* is leading the score followed by *F*, while *D* scored poorly against the five factors.

Table 9.3: SMEs score against the Readiness Index criteria

Six Sigma Readiness Variables	**SMEs scores against the Readiness Index criteria**		
	A	**D**	**F**
Leadership	**3.8**	**1.2**	**2.8**
L1	4	1	3
L2	4	1	3
L3	4	1	2.5
L4	4	1	3
L5	3	2	2.5
Measurement & Process	**3**	**1.8**	**2.3**
M1	3	3	3
M2	3	2	2
M3	3	1	2
M4	3	1	2
M5	3	2	2.5
People Management	**3.8**	**1.5**	**2.5**
P1	3	2	3
P2	4	1.5	2.5
P3	4	1.5	2.5
P4	4	1	2
System and Control	**3.2**	**1.5**	**2.1**
S1	3	1.5	2
S2	3	2	2
S3	3	1	2.5
S4	4	2	3
S5	3	1	1
Customer Focus	**3**	**1.7**	**2.3**
C1	3	2	2.5
C2	3	2	2.5
C3	3	1	1

Reflecting back to the findings from the case study analysis in Chapter 7 and Chapter 8, and comparing it with the performance of three firms against the readiness criteria, it can be said that *A* has already achieved the maturity level required for successful deployment of Six Sigma, as was evidenced from their improvement in financial savings and customer satisfactions from Six Sigma projects. *A* had scored 3 or higher against all the variables included within the five factors of the index. As evidenced from table 9.3, *F* is scoring in the range of 2-3 for most of the variables - indicating and confirming their interest to embark on the Six Sigma journey after full deployment of Lean across the organization (refer to Chapter 7, Section 7.2.2.2 for more information about their interest to embark on the Six Sigma journey). Lack of commitment from top management in *D* resulted in the failure of the Six Sigma initiative and thus their score of 1-2 for variables within the index reflects on their commitment to the CI journey. More detailed analysis of each factor within the index was presented below.

9.2.1. Interpretation of Leadership score in three firms

Leadership is the most important factor to ensure success of any change management initiatives or CI initiatives as evidenced from the literature review and empirical findings. Results from the readiness exercise are in consensus with the empirical findings on quality management practices in company *A, D*, and *F*. Leadership was identified as a ‘bottleneck’ factor in *D* that was holding back their pursuit of the CI journey, as shown in figure 9.1. The change in management in *D* resulted in the shift in focus from initiatives such as Lean/Six Sigma and increasing attention was paid to bottom-line impact and productivity metrics. Lean/Six Sigma was not included in the strategic objectives of the business (L4) and minimal support was provided to drive the CI effort by senior management team (L2). Though *D* implemented Six Sigma for process improvement, they were not culturally ready to embrace and sustain the culture of CI due to lack of strong leadership and top management commitment.

On the contrary, strong and committed leadership was visible in *A* and *F*. The detailed description of the history of the quality journey in *A* and *F* were provided in Chapter 7. Since its inception, *A* had taken incremental steps to embark on the CI journey and at each step the Managing Director had allocated resources and shown commitment for the initiative.

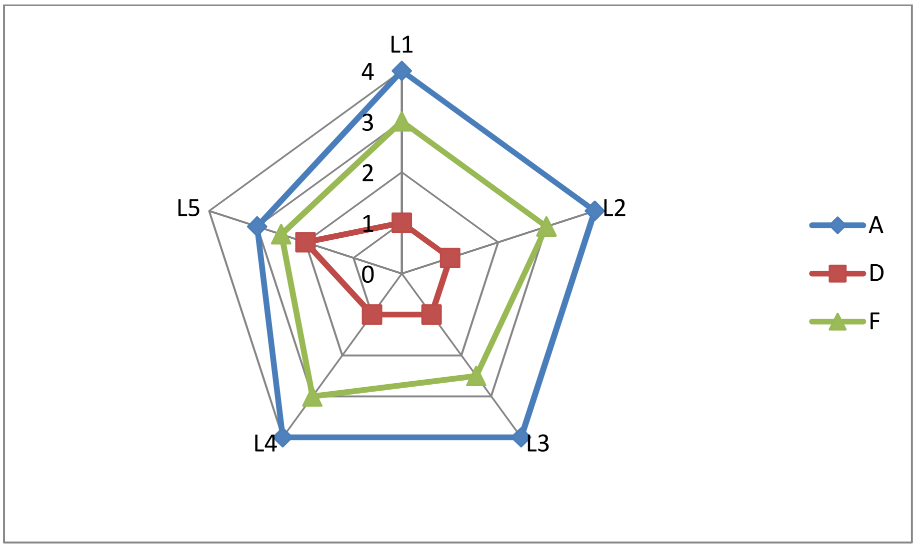

Figure 9.1: SMEs readiness score against leadership dimension

CI was always the top priority and was aligned to the strategic objectives of the business in *A*. The MD believed that initiative such as Six Sigma and Lean may help the company to minimize waste and compete with the low-cost manufacturing countries like India and China. It was thus important, in the viewpoint of *A*, to build a working culture based on the concept of process thinking and fact based decision making. The change in the management team had helped *F* to remain steadfast in its CI journey. Management had realised the benefits from implementation of ISO 9000 and Lean (had just started implementing Lean in 2007) and was committed to move ahead in their CI journey. The score across the five variables of leadership for *F* further substantiate the aforementioned statement. From the leadership perspective, *F* is culturally ready to embark on the Six Sigma journey.

9.2.2. Interpretation of Measurement and Processes score in three firms

The scores for the three firms against the measurement and processes dimension were depicted in figure 9.2. The core business processes in the three firms were known, documented, and key activities within processes were mapped using flowcharts or process maps. This was achieved through adherence to ISO 9000 QMS in the three firms as well as by implementation of Lean in *A* and *F*.

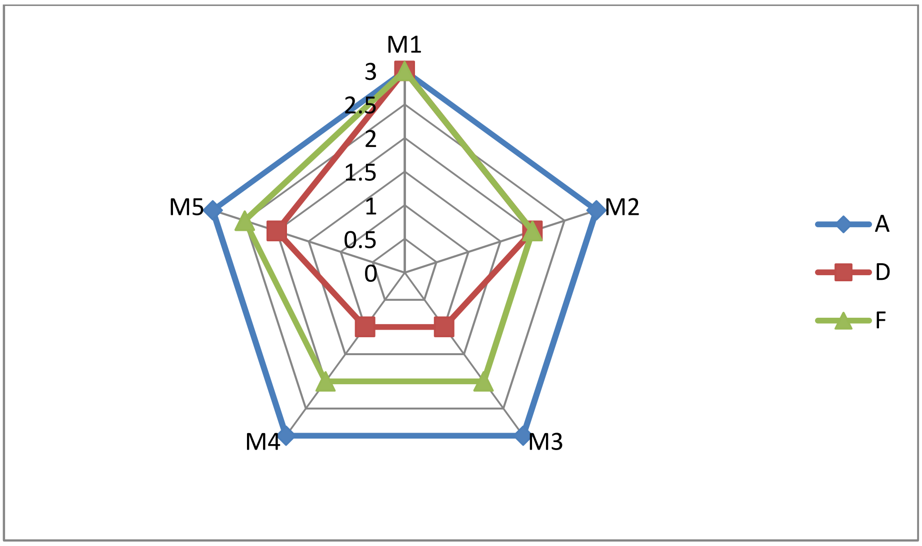

Figure 9.2: SMEs readiness score against measurement and processes dimension

As *A* was already implementing Six Sigma for problem solving, most of their decisions were based on fact and data which had an alignment to the strategic objectives of the business. The benefits generated from the Six Sigma project was measured using established performance metrics and the results were communicated across the organization through intranet, bulletin boards, company newsletters, and MD's debriefing sessions. The MD of *A* ensured that all employees would have an understanding of the basic tools of CI as it empowered them to resolve day-today quality related problems in their processes.

On the contrary, *D* was struggling to adhere to criteria included within measurement and processes (*even though the firm was implementing Lean and Six Sigma*), due to lack of senior management commitment to CI and shifting focus to increasing productivity and profitability at the cost of reduced quality of products and services. Understanding of basic tools of CI was poor in *D*, key performance metrics for the core processes were not established, and decisions were based on the gut-feelings of the senior management team. The change in management of *F* resulted in increased commitment to CI and taking decisions based on fact and data. The company culture had started changing slowly - employees being trained on quality tools and techniques; implementation of Lean tools like 5S and Kanban for minimizing waste from the shop floor; establishing performance metrics for some of their core processes. The management in *F* believed that the company would be ready for Six

Sigma journey in a couple of years once they have fully applied Lean principles to their core business processes, established performance metrics for their processes and trained employees in the basic tools of CI. These slow and incremental steps would facilitate in breaking down any resistance to change by employees and empower them to take decisions for their own business processes.

9.2.3. Interpretation of People Management score in three firms

The score for *A* and *F* with respect to the people management factor were above average (shown in figure 9.3) while *D* struggled to score higher on this dimension as well. The MDs in *A* and *F* believed that the success of any change management program was possible only if they built their human capital, i.e. training and career development of their employees. All employees in *A* were given one day training on Six Sigma to raise their awareness about the efficacy of Six Sigma and how it can help to achieve the strategic objectives of the business. Similar training was provided to employees in *F* on QMS and Lean application. Only middle managers were trained in *D* on Lean and Six Sigma with no involvement of shop-floor employees. Quality management was the responsibility of a handful of managers in *D* compared to company-wide involvement in *A* and *F* (the score of four variables, p1-p4, further reflects their practices).

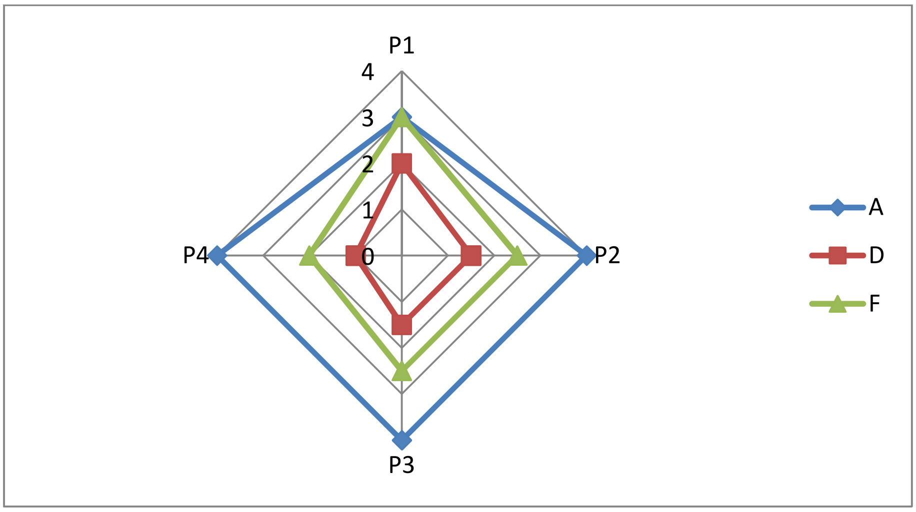

Figure 9.3: SMEs readiness score against people management dimension

Management in *A* empowered shop floor employees to take decisions for their processes and report any discrepancies in product quality to the senior management team. Employees thus take accountability for their processes and avoid a blame culture in the company. As *F* had just embarked on the Lean journey, the change in the company culture was slow but evident. The 5S and Kanban exercise had given a sense of accountability and empowerment to shop floor employees to improve their own processes. Due to weak leadership and lack of vision of the previous MD, the company was still trying to recover from those bad practices where a blame culture was prevalent and staff development was given least priority. The new MD in *F* is making the change happen, but it takes time to involve everybody in this change process. The management in *D* had cut costs on employee training to increase profitability of the company. Quality management was the responsibility of middle managers with shop floor employees given no empowerment to improve their processes.

9.2.4. Interpretation of Systems and Control score in three firms

The scores in the first three factors of the Readiness Index may have an effect on systems and the control dimension. The results from the table 9.3 and figure 9.4 indicates that *A* had well established systems and controls in place that may be attributed to their performance in the first three factors of the index. Strong leadership, established measurement and processes, and people management led to the establishment of proactive quality systems, standardised procedures, and top-down communication. Management realised the importance of forming a cross-functional team for executing Lean/Six Sigma projects as participants from other functions would look at the production problem from fresh eyes and may have different ideas for problem solving compared to production staff.

Employees in *F* had strictly adhered to ISO 9000 principles to establish standardised processes and regularly review their processes for improvement. In terms of establishing good communication systems and proactive quality systems, the new management team were devising ways to improve it at the time when the case study was conducted. Similar to the majority of manufacturing SMEs, the problem solving team involved people from production or the shop-floor with minimal involvement of employees from other departments of the organization.

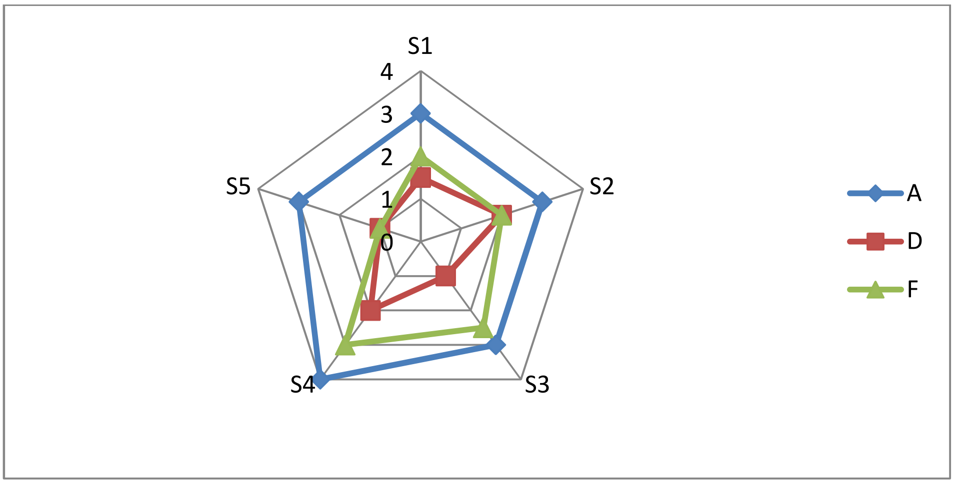

Figure 9.4: SMEs readiness score against systems and control dimension

It is imperative to improve on the aforementioned factors before *F* embarks on the Six Sigma journey. Lack of strong leadership and poor measurement systems had an impact on the establishment of systems and control in *D*. They scored very low for the five variables included within the systems and control dimension of the Readiness Index. Six Sigma / Lean and ISO 9000 certification seemed to be a window dressing exercise for management in *D* to increase market share and improve customer retention rate. All the aforementioned factors had resulted in the failure of the Lean/Six Sigma initiative in *D*.

9.2.5. Interpretation of Customer Focus score in three firms

Employees in *A* regularly seek customer feedback to understand their expected performance from the firm's products/services, understand their causes of concern and any major customer complaints issues. The MD along with the marketing and sales teams in *A* used to meet their key clients to understand their product/service requirements and expectations. Any customer complaints were given top priority and were resolved on an immediate basis. With the implementation of the Six Sigma strategy, the company started capturing the true voice of the customer (VOC) and tried to identify value-added and non-value added steps from the customer perspective. Management and employees took proactive measures to minimize the complaints from the customer end. The scores for the three firms against the customer focus dimension were depicted in figure 9.5.

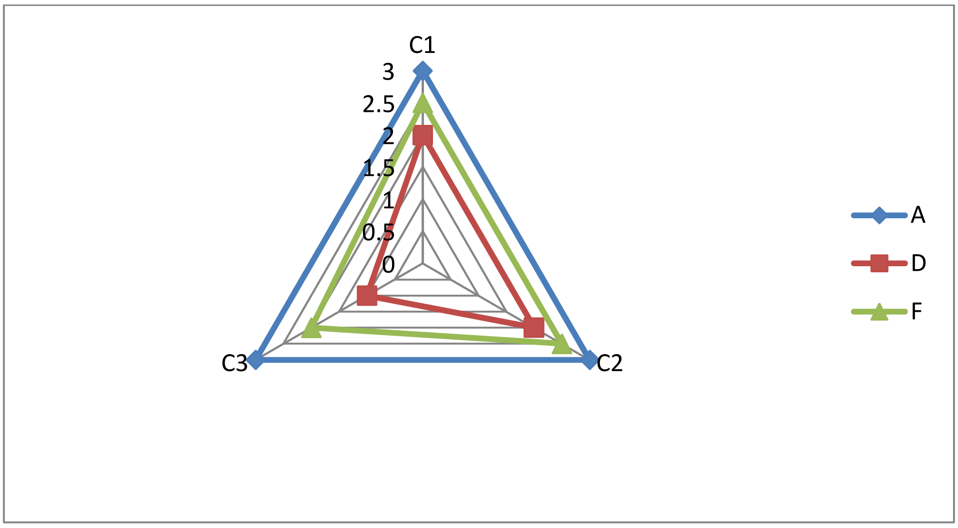

Figure 9.5: SMEs readiness score against customer focus dimension

Whereas both in *D* and *F,* customer complaints was the measure used to capture VOC, which could be regarded as a reactive mode of operation, i.e. reacting after the problem had already occurred. As Six Sigma was used as a window dressing exercise for *D*, there was a lack of a proactive system to capture true VOC or identify value-added activities or non-value added activities from the customer perspective. Customer surveys were conducted in *D* but that data was rarely analyzed to understand issues from the customer perspective. Due to strict adherence to QMS and Lean, *F* had slowly started taking proactive measures to capture VOC (e.g. customer survey, trained employees to understand customer issues) and understand the non-value added activities from the customer perspective. It is imperative for the management in *F* to be involved with their key customers and resolve their major concerns on an immediate basis. This will prepare them for their Six Sigma journey, where everything starts from the customer and ends at the customer.

9.3. A final thought on Six Sigma Readiness Index

The results of the readiness exercise in three SMEs reflects on their actual commitment to quality management practices and are in consensus with the case study findings discussed in Chapter 7. The findings from Chapter 7 clearly indicated the high level of commitment from the MD of *A* to support and sustain the benefits realised from Six Sigma implementation. The readiness score of *A* also reconfirm their firm's maturity in the application of Six Sigma. The management in *F* indicated their desire to implement Six Sigma, as discussed in Chapter 7, after they have streamlined their business processes, established performance metrics for core processes, developed basic understanding of tools and techniques of CI, and developed their human capital. The readiness score for *F* indicates that they need to improve on four dimensions of the index - measurement and feedback; people management; systems and control; and customer focus, before they embark on the Six Sigma journey. The readiness score of *D* reflects their culture of working in a reactive mode of operation and poor commitment to quality management practices, as also evidenced from case study findings. The readiness score for the three firms had managed to capture their existing commitment to quality management practise and their continuous improvement journey. It may be commented that the index had managed to capture the data for which it was designed, thus addressing the issue of validity of the instrument. *The journey to continually improve the readiness index has just begun. More comments from Six Sigma practitioners and industry executives would be taken in future to further refine the readiness index.*

9.4. Six Sigma Implementation Framework for SMEs

Six Sigma builds upon many of the successful elements of previous quality improvement initiatives and incorporates a unique method of its own. Although the financial payback from Six Sigma projects allurers many companies to embark on its implementation journey, but they need to carefully consider the implementation process to ensure sustainability and long term benefits from the initiative. The author has developed a Six Sigma implementation framework that will act as a roadmap or guidelines for SMEs to follow in their effort to improve continuously, maintain high standards of quality and enhance their chance of success in embracing this program. The company wide implementation of Six Sigma can take place in five phases, as proposed in the framework, starting from assessing the readiness for Six Sigma implementation to sustaining the benefits from the implementation, as illustrated in figure 9. 6.

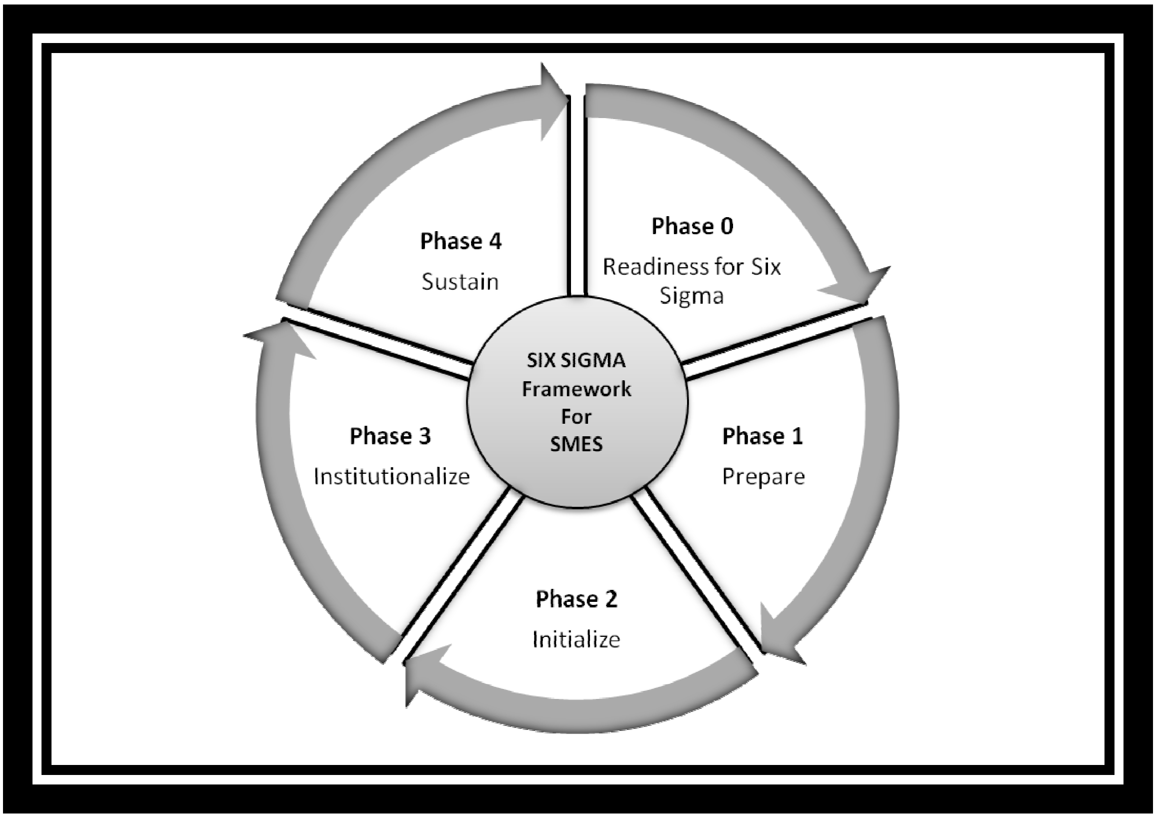

Figure 9.6: A five phase framework for Six Sigma implementation in SMEs

To date, no research projects or literature have proposed a generic implementation framework to get started with Six Sigma in a SME environment. This framework was developed by critically analyzing the quality frameworks/models proposed by researchers and matching these with the findings from the two phases of doctoral research. The five phases of the Six Sigma framework was influenced by the frameworks/models proposed by researchers in the past such as Ghobadian and Gallear (1997), Yusof and Aspinwall (2000c), Husband and Mandal (1999), Deros *et al* (2006) and Khan *et al* (2007). The critical success factors and challenges identified from this empirical research was compared with the existing frameworks/models proposed for SMEs to design the five phases of the proposed Six Sigma framework customized to the needs of SMEs.

The first decision of where to begin is so difficult that many organizations never get started. If the implementation of Six Sigma is planned at organization-wide level, then organization-wide support must be in place well before the Six Sigma project begins. The proposed twelve steps, as shown in figure 9.7, in the five phases of the framework will facilitate SMEs to apply Six Sigma in a systematic and logical manner.

Though few steps of the framework are generic and applicable to all type or size of firms, step 3-5, step 8, step 10, and step 12 were designed specifically for SMEs taking into consideration the characteristics of SMEs and constraints faced by them. For detailed information about each step of the framework, please refer to Section 9.4.1-9.4.4.

The framework was tested in three SMEs by conducting semi-structured interviews with the middle management teams (the interviewees shortlisted for readiness test participated in the framework testing as well). The comments and suggestions from the interview process were incorporated in the framework to make some minor amendments in the details of step 3, step 6, step 8, and step 12. The Six Sigma framework presented in figure 9.7 is the revised framework that will facilitate SMEs to successfully implement Six Sigma and become resilient to tackle quality challenges in the global market.

The first phase of the framework, i.e. Phase 0, tests an organizational readiness for Six Sigma implementation. The Readiness Index was discussed in detail in section 9.2 and 9.3. The readiness exercise would ensure that SMEs achieving the threshold value smoothly sail through Six Sigma implementation without any major disruption. This is the first step to build resilient SMEs that can sustain the benefits from Six Sigma implementation on a long-term basis. The readiness criteria are the energy force to drive Six Sigma success, the lack of which may not lead to long-term improvements irrespective of how well other criteria in the framework had been addressed. *SMEs that achieve the threshold value in the readiness test are ready to embark on Phase 1 of the framework for Six Sigma implementation*. The next section discusses the steps involved in of Phase 1 of implementation of the framework.

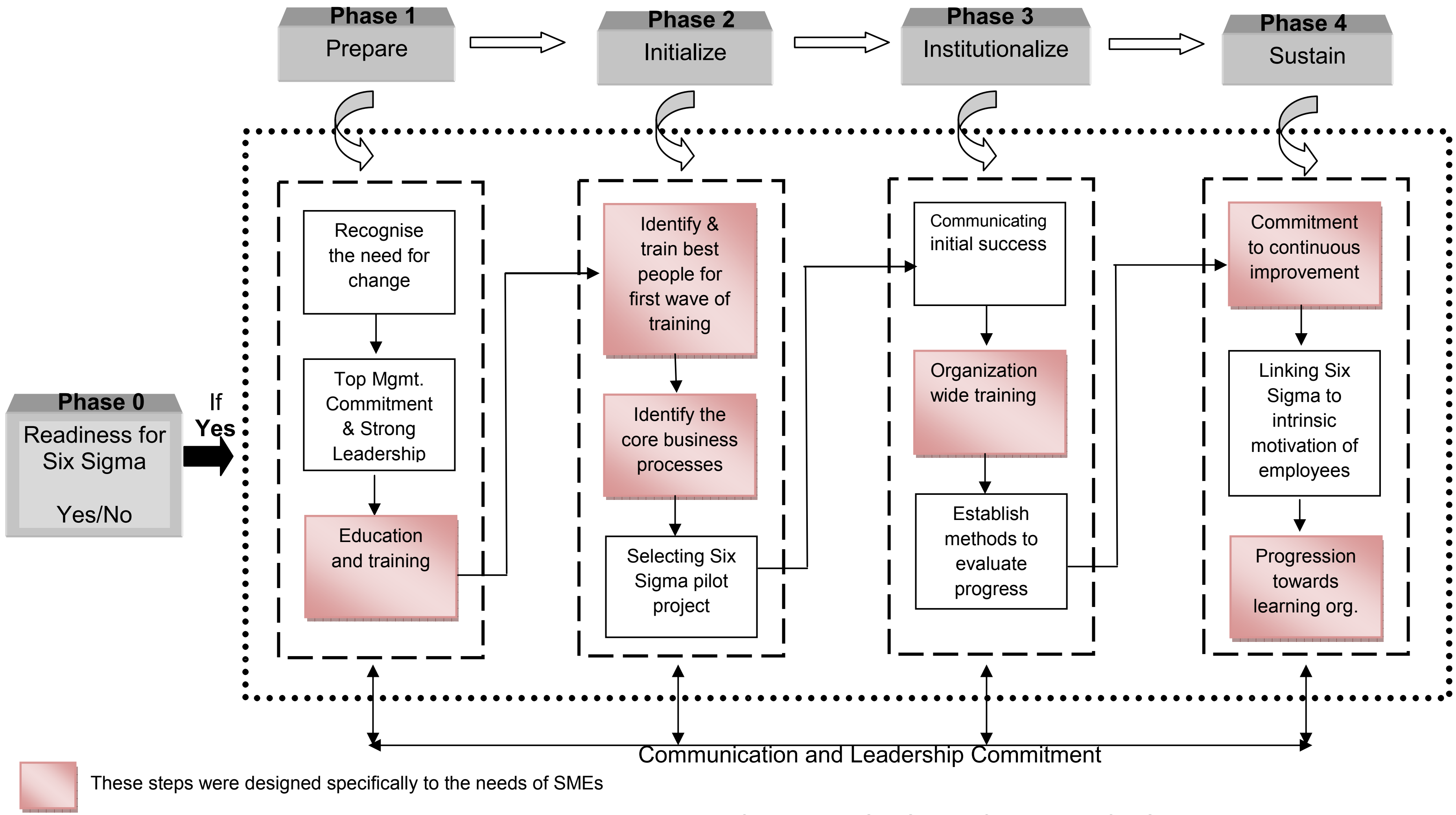

Figure 9.7: A 12 step approach in the five phase Six Sigma framework for SMEs

9.4.1. Phase 1- Prepare

The Prepare Phase helps an organization to understand the rationale behind the change and measure the commitment from senior management team to invest time and allocate resources for implementing the change. The preliminary stage of understanding the need for change and commitment from the top management are vital steps which form the foundation of the whole Six Sigma framework.

Step 1: Recognise the need for change

The framework begins with the identification of the need for Six Sigma and justification for its launch. This need for change may be externally driven by customers and markets and internally driven by the employees (i.e. internal customer). A list of internal and external variables that drive the change is listed in table 9.4. The need to implement Six Sigma may be due to pressure from the original equipment manufacturer (OEM) / customer to reduce the errors or defects in its product or service delivered. Outsourcing to low cost manufacturing/ service countries, decline in market share, or change in government policies and regulations may force management to think about the need for Six Sigma implementation.

Table 9.4: Main factors driving the need for Six Sigma

External Factors	Internal Factors
Customer complaints/ requirement	Performance improvement
Market competition	Process improvement
Regulatory demands	Employee satisfaction
Government policies	Changing business focus
Outsourcing	Management change

(*Adapted from: Oakland and Tanner, 2006, 2007; Dale et al., 1997*)

These external factors may be intertwined with the internal factors driving the change. For example, customer complaints may force internal factors such as process or quality of product to improve. Conducting the business review and gap analysis would facilitate in identifying the strengths and weaknesses of the organization and also prioritizing the potential change needed. It is imperative to note that if a business is going through restructuring that requires significant layoffs or a merger, creates uncertainty and too little executive attention, then Six Sigma is not a way forward.

Step 2: Strong leadership and Top Management commitment

Once a SME pass through Six Sigma readiness test, it gives an indication that the firm had a strong leader supporting CI activities in the past. Again, this commitment from top management and leaders needs to be reassessed at the start of the Six Sigma implementation.

Six Sigma works best with a top-down approach- when the CEO and senior management team own it, support it, and drive it (Pande *et al*., 2000; Antony and Banuelas, 2002). This is the most important aspect to start with because many companies have failed in their attempt to implement Six Sigma either due to lack of commitment at the managerial level or due to lack of strong leaders to drive the initiative. Communication plans should be developed and deployed so that all senior management team are aware of the quality improvement effort and understand why it is being implemented. SMEs have the advantage of faster communication across the business due to their flat layer structure and less functional hierarchy.

Leadership from top of the organization is necessary to define, prioritize and construct the quality thinking in the organization. GE success with Six Sigma was due in large part to the role that Jack Welch (former CEO) played in relentlessly advocating the initiative and integrating it into the core of the company's strategy (Mekong Capital, 2004). It is desirable that senior management approves the Six Sigma initiative, defines the purpose and scope of Six Sigma, and links it to the mission and vision of the organization. If the business leaders and their team cannot invest two days of their own time in learning more about Six Sigma and their role, then they are not ready to start (Pande *et al*., 2000). Some of other roles and responsibilities of senior management and their performance measures is cited in table 9.5.

Table 9.5: Responsibilities and performance measures of top management

Factor	Main Responsibilities	Performance measures
Leadership & Senior Management commitment	• Linking Six Sigma to company's mission, vision, and values • Making Six Sigma one of the top three priorities of the business • Communicate the need for Six Sigma • Ready to address any resistance to change • Breaking down stumbling blocks or barriers to implementation • Motivate and support the employee in the implementation process	• Develop a strategy for deployment • Develop a 3-5 years strategic Six Sigma plan • Allocate budget and resources • Introduce incentive and reward schemes • Control through visibility • Monitor progress • Committing themselves for one or two days training on Six Sigma

(Adapted from Motwani, 2001; Writer, 2007)

Step 3: Education and Training at Senior Management Level

To constantly maintain competitive edge and effectively transfer knowledge throughout the organization, it is important to start training at the top of the organization and this should then be cascaded down through the organizational hierarchy (Antony and Taner, 2003). Education and awareness sessions will secure senior management commitment and faith in the initiative. The literature review and the empirical study explicitly stated resource constraints (financial, technical, time) faced by SMEs for implementing any change. The best way forward for SMEs to negate the effect of resource availability on the implementation process is to network or collaborate with their OEM / organizations adopting Six Sigma or government bodies or academic institutions for training and support during the initial phase of Six Sigma implementation (Kumar and Antony, 2009; Thomas and Webb, 2003; Thomas, 2007; Thomas *et al*., 2008; Hewitt, 1997; Shea and Gobeli, 1995; Barrier, 1992). This step will minimize their expenses in hiring expensive consultant to train their employees.

Government bodies in the UK such as the Manufacturing Advisory Services (MAS) provide help to SMEs to streamline their processes, reduce waste, become more energy efficient and improve their business at free cost or at highly subsidised rates (http://www.mas.berr.gov.uk/). Local universities can help SMEs in several ways to embark on their CI journey- train on statistics concepts, principles of Lean, Six Sigma, tools & techniques of CI; internship students available to work on the Six Sigma project supported by an academic mentor. SMEs can take advantage of free support available from social/professional networks on the internet such as – www.isixsigma.com, International Society of Six Sigma Professionals (ISSSP), and LinkedIn, to name a few. The development of a network will facilitate SMEs to share their experiences of implementing CI initiatives or using self-assessment tools with similar companies on a common platform.

The action plan for this step is listed below:

- Educate senior management team with executive or champion training
- Create a Six Sigma steering committee comprising the top management (Writer, 2007) to provide leadership, co-ordinate the review of on-going projects, liaise with champions of different projects and allocate resources to them, ensure the projects selected have strategic links to business objectives
- Identify and select executive leaders to drive the initiative

9.4.2. Phase 2- Initialize

The Initialize phase helps an organization to implement the change on a pilot basis by identifying, selecting and motivating the few talented employees to be the part of the change and selecting a pilot project for execution that can be completed within short span of time with maximum impact. The Initialize phase builds momentum for deploying change across the organization.

Step 4- Identify and train best people for the first wave of Six Sigma

It is indispensable to attract the best people with good leadership skills to be involved in the company's first wave of training on Six Sigma (Pande *et al*., 2000; Pyzdek, 2003; Antony, 2004). There are three major reasons why top talent is so important to the Six Sigma effort (Snee and Hoerl, 2003):

- The better the talent, the better the result

- Top talent attracts more top talent
- Top talent becomes the next organizational leader

Selection of top talent for the key roles gives a clear message to the organization that management is committed and serious about Six Sigma. This will provide an impetus and motivation for other employees to get involved in the initiative. Selection criteria should be developed by top management in selecting the right people for the first wave.

Taking into consideration problem complexity and resource limitation, SMEs do not require an extensive role system where Master Black Belts, Black Belts (BB) are involved in projects as are applied to large organizations (Kumar *et al*., 2006, 2008). Findings from empirical research (Kumar and Antony, 2008, 2009) indicate the need of 1-2 Black Belts for a firm with 250 employees. In the first wave of training one, or a maximum of two employees from the firm (top talented people in the firm should be selected) should be selected for Six Sigma Black Belt training. The Black Belt can then train the rest of the employees, by taking train the trainer approach, at different levels of Six Sigma expertise, i.e. Green Belt (for middle managers) and Yellow Belts (for supervisor and shop floor employees).

There is no need for Master Black Belt in a SME environment and the focus should be on training more Green Belts (in the second wave of training) as suggested by case study firms, Six Sigma practitioners from MAS, and delegates at the 3rd International conference on Six Sigma. Estimated savings from a Black Belt project in a SME environment is different from that in large organizations. A typical BB in large organizations is expected to save approximately £75k per project; whereas in a SME environment, BB may save £30-£35k per project (supported by empirical research conducted by author, though no such figure is available in the literature). *The requirement of BB and typical savings from BB projects in a SME environment is an unexplored area of research that requires further investigation and development.*

Key points to consider during the execution of step 4 are:

- Select best people from all departments of the organization
- Identify the best training provider in the area that has got reputation and experience in delivering training (e.g. MAS, University offering BB training, or a reliable consultancy company of international repute).

- Develop training plan/schedule.
- Identify and train candidates for Six Sigma project Champion and BB roles.
- Form one or two cross-functional teams for the first wave, comprising not more than 6-8 members in each team. The team members should be the interested parties from different functional groups such as Production, Research & Development, Marketing & Sales, Finance, or Human Resources. The involvement of members from other functional groups will provide more ideas and fresh angle to the problems.

Step 5: Identify the core business processes

Identification of core processes is an area of potential bottleneck for many organizations because, if the core processes are not known, the rest of the framework is difficult to implement (Oakland, 2003). It becomes easier to understand the business, processes, and identify opportunities for improvement, if the process mapping / value stream mapping (VSM) for the core processes have been performed. Adherence to ISO 9000 guidelines or implementation of Lean before embarking on Six Sigma establishes standardised systems and procedures, identifies core and support processes, and develop VSM for key processes. VSM projects the bottleneck operations or chronic problems by identifying value-added and non-value added activities in the value stream. The pre-established system like this in SMEs may aid in Six Sigma implementation.

It is preferable to launch Six Sigma by focusing on a few strategic areas, rather than 10 or 20 (Snee and Hoerl, 2003). It is equally important to establish the process performance measures, which could be used to define what is important for success and which are used to select the project. Activities involved in this step are:

- Identify core business processes and prioritize critical processes (if not identified in the readiness assessment stage, i.e. phase 0).
- Develop the process map or value stream map for the core processes.
- Develop a measurement plan and metrics for the core processes, e.g. cost of quality; value-added or non-value added activities (It is worthwhile to identify,

isolate, and remove measurement variations, which would lead to the actual measured values obtained from the measurement process)

- Establish performance metrics for the critical processes.
- Review the current performance for the critical processes.
- Perform the internal & external benchmarking for the critical processes.
- Identify and prioritize those processes that have greater stakeholder and financial impact.

Step 6: Selecting Six Sigma pilot project

Projects are the core activity driving the change in Six Sigma organizations. As quoted by Snee and Hoerl (2003), "*Project selection is a critical component of success. Often the battle is lost before we have even begun due to selection of poor projects*".

Some early wins are crucial and necessary to buy-in management and company-wide commitment for the initiative. Primarily, initial pilot projects should focus on key problem areas (as identified in step 5) with strategic alignment in terms of high customer satisfaction and critical to business success in terms of faster or larger financial return (Kumar *et al.,* 2009; Pyzdek, 2003). Only those projects should be selected at the start of the implementation process that could be completed in the shortest possible time (3-4 months) with less effort and high impact in terms of productivity and profitability (Barrier, 1992; Struebing and Klaus, 1997). The process performance measures determined by the senior management facilitate everyone to focus on the initial projects strategically (Snee and Hoerl, 2003). The success of the pilot project would act as a model for the rest of the organization to follow. It is desirable that the finance department is involved from the beginning of the project to ensure that the cost-benefit analysis is carried out for each Six Sigma project and savings are actually reflected in the bottom-line.

9.4.3. Phase 3- Institutionalize

The Institutionalize Phase refers to the deployment of Six Sigma across the organization so that the culture of process thinking, statistical thinking, and CI is embedded within the organization.

Step 7: Communicating the initial success

All financial and strategic savings generated from pilot projects should be reported upon project completion. Awareness and recognition of all employees on Six Sigma pursuit is achieved through the communication of Six Sigma savings. The senior management team should communicate carefully to the whole company as why they chose to deploy Six Sigma, what they hope to get out of it, and where it will take the organization (Snee and Hoerl, 2003). Different communication strategies or media such as intranet, newsletter, bulletin board, etc should be used. Important points to consider in this step are

- Celebrate and widely share the success of pilot projects.
- Gain the appreciation of top management as well as members of supervisory teams.
- Share the major challenges and pitfalls during project execution

Step 8: Organization-wide training

A sound organizational infrastructure for each of the Six Sigma roles (Black Belt (BB), Green Belt (GB), Yellow Belt (YB)) is a key element for institutionalizing the Six Sigma initiative within the fabric of the organization. It is not only important to allocate resources for a wave of mass training, but also to identify all the training needs of all the roles, and put together a sustained, ongoing system to continuously satisfy these needs in the most efficient way possible (Snee and Hoerl, 2003). Training should not just be short-term but should involve educating on the long-term basis, with regular training follow-ups and briefings (Antony and Taner, 2003).

As discussed in step 4, BB can take the *'train the trainer approach'* to train rest of the employees at GB or YB level. This will not only save financial resources for SMEs, but also build their own capability and understanding of Six Sigma for long-term sustainability of the initiative. This approach was popular and practised by participating case study firms in this study. It is also advisable in the authors' opinion to develop a White Belt system for SMEs instead of heavily investing in the Black Belt system (Kumar *et al.*, 2008). The White Belt definition provided by Harry and Crawford (2004) is not realistic and achievable. Twelve projects in a year for a White Belt are too ambitious. The author suggests that the White Belts may carry out between 4 to 5 process or quality improvement related projects using the DMAIC methodology. The expected savings from a White Belt project can be around £5000 per project. In our opinion, a company of size 100 should plan for about 10 to 15 White Belts, trained for a week on basic Six Sigma methodology. *This is gray area of research that needs further exploration and testing.*

Other components of the supporting infrastructure that become key in this step are:

- A steering committee comprising the senior management people formed and active (discussed in step 2)
- Executives trained at GB and BB level should execute a project linked to the strategic goals of the business and demonstrate potential savings generated from the project. Once the project is executed, the GB/BB should be rotated back to their original job and opportunity should be given to other employees to execute projects. This way SMEs can take care of their scarce human resources as well as build up their own knowledge intensive workforce
- Continual training for new employees as well as experienced GBs
- Training should not only focus on statistical tools and techniques application but also on softer issues such as change management, leadership, culture issues, to name a few.
- Audits should be carried out to ensure that completed projects are continuing to reap benefits (Snee and Hoerl, 2003)

Step 9: Establish methods for evaluating progress

The gap analysis conducted in the first-phase will help to identify the critical business processes and establish the metrics to measure the performance of those processes. Good performance measurement allows target areas for improvement to be identified and has a key role in communication (Oakland and Tanner, 2006). These metrics should regularly be monitored and reviewed by the Six Sigma team. It is equally important to measure the non-financial metrics such as customer satisfaction, employee satisfaction, job involvement and commitment, to name a few, which are the key indicators of any change initiative. Key points to be accentuated upon in this step are:

- Develop standard procedures and system for results recording and reporting.
- Highlight the successful as well as poor results and feedback to employees
- Members of supervisory team accountable for reporting results for their individual processes.
- Establish monthly review of on-going projects, identify performance trends, evaluate progress and revise strategies.

9.4.4. Phase 4- Sustain

The Sustain Phase emphasizes on how the learning from the first three phases could be shared, transferred and applied across the organization to continue reaping benefits on a long-term basis from the implementation of Six Sigma. The idea behind including this phase was to make sure that the benefits and knowledge generated from Six Sigma projects are sustained on a long-term basis.

Step10: Commitment to Continuous Improvement

Sustaining improvement is a challenging task, where many SMEs struggle due to a change in business focus or fluctuation in economy. To keep the momentum going, it is necessary to develop generations of managers, who not only understand but are dedicated to the pursuit of continuous improvement in meeting external and internal customer needs (Oakland, 2003). This is the first step towards long-term sustainability of the initiative, facilitating in the creation of resilient SMEs.

Step11: Linking Six Sigma to intrinsic motivation of employees

Employees are the source of ideas and innovation, and their expertise and knowledge should be harnessed to get those ideas implemented (Oakland, 2003). Management should believe in the power of ‘intrinsic motivation’ (self-motivation) rather than solely relying on ‘extrinsic motivation’ [coerced or bribed to do it] (Snee and Hoerl, 2003). The intrinsic motivation can be generated through:

- Employee involvement in project improvement teams or review meetings
- Employee empowerment for their processes
- Training and development for their career progression
- Reward and recognition scheme (Antony and Banuelas, 2002)

The aforementioned features were evidenced in the participating case study firms during the empirical research.

Step 12: Progression towards learning organization

According to Senge *et al* (1999) **learning organizations** are *“organizations where people continually expand their capacity to create the results they truly desire, where new and expansive patterns of thinking are nurtured, where collective aspiration is set free, and where people are continually learning to see the whole together”.* The basic rationale for such organizations is that in situations of rapid change only those that are flexible, adaptive and productive will excel. A progression towards becoming a learning organization would ensure Six Sigma SMEs to sustain benefits in the long-term. Some of the key elements that an organization should focus on to become a learning organization are:

- Regular project review meetings and briefings to enable both management and employees to share experiences and progress on projects, and factors critical for its success and failure (Senge *et al*, 1999)
- Individual and organizational learning should be actively encouraged (Kaye and Anderson, 1999)
- Benchmarking of an organization’s activities and its progress with internal (within department) and external competitors
- Regular review of employee training needs, evaluation of their performance and feedback for improvement

As shown in figure 9.7, communication and leadership commitment plays a key role in all the four phases for successful implementation of Six Sigma. An early and informed strategy for implementation is always necessary and decisions about rolling out the program in segments or as a whole is often determined by the culture within the company, time available and the current needs of the organization. In implementing the framework, it is important that communication of information is effective and that accountability is explicit and supported by committed senior management team and strong leaders. Top leaders should make themselves available for staff, keep in touch with staff and communicate with all managers about the long-term strategies of the organization. Middle managers play a key role in the success of any change program (Snee and Hoerl, 2003; Kaye and Anderson, 1999) and their confidence in the initiative is equally important. Kaye and Anderson (1999) quoted the following finding in their survey study "*Senior management walk around quite a lot and observe. Formal systems won't tell them how good quality is, they need to get out there*".

9.5. Summary

The implementation of Six Sigma has not been an easy task for many organizations. Very little has been published on the implementation aspects of Six Sigma, such as where to get started or how to get started, etc. The key practical contribution of this doctoral research is the development of the Six Sigma Readiness Index and the Six Sigma implementation framework tailored to the needs of SMEs. Both was developed based on the review of the literature and key findings from an empirical research conducted over a 3 year period. The literature identified very limited frameworks that were designed for the needs of SMEs, taking into account their characteristics and weaknesses. The key findings from multiple case-studies in 10 SMEs led to the understanding of key constituents required to build a Six Sigma Readiness Index and an implementation framework for SMEs.

The Readiness Index was designed to identify areas of strengths, weaknesses, and opportunities for improvement in the organization's quality management practices. The purpose of the exercise was to assist SMEs in making right decisions in the development of a Six Sigma strategy for achieving and sustaining competitiveness. The cultural readiness and maturity to embark on the Six Sigma journey were evaluated and tested within three SMEs. Findings from the readiness exercise were critically analyzed to check the validity of the index.

The framework provided a structured and step by step approach for implementing Six Sigma in a SME environment. It is not only imperative to drive improvement from implementation of Six Sigma initiatives but also to sustain the gains over the long-term. Phase 4 of the framework suggests the ways to sustain the benefits from Six Sigma implementation by focusing on intrinsic motivation of employees and sharing the learning across the firm. The sustainability dimension would accoutre SMEs to absorb the ripple caused due to any external disruption and make them more resilient to such changes. The practical applicability of the framework would be further tested by conducting case studies in companies and also seeking suggestions for improvement from world-class organizations, academics, and practitioners of Six Sigma. The author is also working on establishing the time frame for the implementation of each phase of the framework in consultation with Six Sigma experts in academics and industry.

Chapter 10

Conclusion

10.0. Introduction

As stated in Chapter 1, this research was undertaken to assess the status of Six Sigma implementation in the UK manufacturing SMEs and thereby develop a customized practical framework to facilitate successful implementation of Six Sigma in SMEs. This exploratory research identified the research gap in terms of application of Six Sigma in a SME environment (Antony *et al.*, 2005, 2008; Kumar, 2007)- the business strategy that has resulted in generating significant savings for many large organizations (Snee, 2004; Hoerl, 2004; Kumar *et* al., 2008; Gutierrez *et al.*, 2009; Antony and Desai, 2009). Researchers have focussed in the past on TQM implementation in SMEs, CSFs and barriers of TQM in SMEs, framework and model for TQM implementation in SMEs, and impact of TQM on organizational performance of SMEs (Ghobadian and Gallear, 1996; Yusof and Aspinwall, 1999, 2000 a, b, c). Author was inspired by the study of Ghobadian and Gallear (1996) and Yusof and Aspinwall (1999, 2000 a, b, c) on TQM implementation in SMEs and further extended it to explore the status of Six Sigma implementation in SMEs.

As there were limited articles published on Six Sigma in SMEs, this research attempted to answer the five research questions, discussed in the next section, to make a contribution to the theory and practice of the Six Sigma body of knowledge. This chapter briefly summarises the key findings from the doctoral research and discusses how the quality criteria established in Chapter 5 was addressed for this research. The quality criteria section addresses the reliability and validity of the research, and its contribution to the theory and the practice. Limitation of research and agenda for future research was discussed towards the end of this chapter.

10.1. Key Findings from Empirical Research

RQ1: *What makes SMEs different from large organizations?*

The literature suggested differences in the characteristics of SMEs compared to large organizations with respect to criteria such as management style, strategic planning, systems and procedures, resource availability, organizational structure, operational improvement, and networking (Ghobadian and Gallear, 1996, 1997; Yusof and Aspinwall, 2000 a, b; McAdam, 2000; Phelps *et al*., 2007; Kumar, 2007; Antony *et al*., 2008). The findings from the empirical research were in consensus with the literature review. Leaders and senior management in a SME environment were seen to have more understanding of processes, operational issues, and customer requirements a compared to those in large organizations. The advantages of SMEs over their larger counterparts lie in their effective and open communication channels, low resistance to change, people orientation, functional integration, and innovativeness. However, SMEs face disadvantages in the continuous search for operational improvement, allocation of resources for training and staff development, economies of scale, lack of forward planning, cash flow problems, lack of investment at the right time, lack of business experience, little or no external help and limited customer bases. The participating firms faced the challenge of resource availability to apply Six Sigma. They also struggled to establish a close network with government bodies and academic institutions in seeking support on CI training and projects. This is among very few studies in the quality management (QM) literature that presents the differences in the characteristics of SMEs and large organizations through the lens of small business growth models. It also identified the similarity in the critical success factors (CSFs) stated for small business growth and for the implementation of CI initiatives in SMEs. The interviewees were in consensus that it would be difficult to decide on the implementation of a CI program, e.g. making a transition from ISO certification to Lean/ Six Sigma implementation, depending upon their positioning on the growth model.

***RQ2:** What are the critical differences in quality management practices of Six Sigma and non-Six Sigma SMEs?*

The survey response clearly indicated that very few SMEs are aware of or have understanding of the Six Sigma initiative. It can be commented that Six Sigma is at its rudimentary stage in terms of its application in the UK SMEs. Lean was the second most popular initiative in SMEs after ISO 9000 certification. The findings from this study gave an indication, similar to findings from literature (Gotzamani, 2004; Gotzamani and Tsiotras, 2002), that a good QMS such as ISO may be the foundation or building block to embark on the Six Sigma journey. The implementation of Lean before Six Sigma was favoured by interviewees for quick gains and minimizing the resistance to change by employees (Khan *et al*., 2007). Chapter 7 and 8 clearly indicated on the difference in QM practices of Six Sigma firms and non-Six Sigma firms with respect to tools and techniques used for problem solving, organizational infrastructure, motivation to embark on the quality journey, and customer focus. Findings from the literature also indicated the positive impact of TQM on the QM practices of SMEs (Rahman, 2001; Lee, 2004; Ghobadian and Gallear, 1996; Yusof and Aspinwall, 2000b) as compared to firms having only ISO 9000 certification (McAdam and McKeown, 1999; Gotzamani, 2004; Gotzamani and Tsiotras, 2002). The majority of Six Sigma firms had committed management team, established systems and procedures, had a dedicated cross-functional team for problem solving, used tools and techniques of quality for problem solving, involved people from accounting and finance departments to quantify the benefits from Six Sigma projects, and were in regular contact with customers to understand their needs and requirements. Such characteristics were missing from the non-Six Sigma firms. The resource availability for education and training of employees was more prevalent in the Six Sigma firms as compared to the non-Six Sigma firms. The Six Sigma firms used the ‘train the trainer’ approach as well as rotation of employees involved in Six Sigma project to develop a sustainable organizational infrastructure for a long-term sustainability of benefits realised from Six Sigma.

RQ3: *What are the critical success factors and barriers to implementation of Six Sigma in SMEs?*

Factors identified as critical to the success of the Six Sigma program in SMEs from surveys and case study analysis were strong leadership and management commitment, education and training of employees, communication, cultural change, employee empowerment, role of middle manager, and networking with government bodies, academic institutions, and OEMs. *Networking and the role of middle managers emerged as new factors from the case study analysis, which was least cited in the previous study*. The empirical findings also indicated that the aforementioned factors are equally important for any type and size of firms irrespective of the type of initiatives being implemented in the firm-whether it is Six Sigma, TQM, Lean, or ISO 9000 QMS. Resource availability to implement CI initiatives or certification systems and to sustain the benefits on a long-term basis were cited as the most common impeding factors in the empirical research as well as the literature (Antony *et al*., 2005, 2008; Kumar, 2007; Yusof and Aspinwall, 1999, 2000b; Ghobadian and Gallear, 1996, 1997). However, interviewees viewed scarcity of resources as an excuse by top management for not implementing CI initiatives in SMEs. Other barriers to implementation of Six Sigma in SMEs were identified as lack of knowledge, poor training/coaching, internal resistance, poor employee participation, lack of senior management commitment, etc.

RQ4: *Does the performance of Six Sigma firms differ from non-Six Sigma firms?*

This is among very few studies that had conducted a comparative analysis of performance of Six Sigma firms and non-Six Sigma firms. The majority of SMEs embarking on the Six Sigma program had established performance metrics that were regularly monitored to track the benefits from Six Sigma projects. The savings generated from Six Sigma projects, as discussed in Section 7.1.4.2, clearly outweighed the initial investment made at the start of the program. SMEs in the non-Six Sigma category had less established systems and procedures, and performance metrics to measure their process performance. Significant differences were observed between the Six Sigma firms and the non-Six Sigma firms with respect to their scores for operational and strategic performance metrics. SMEs realised significant improvement in their established performance metrics after implementing Six Sigma as compared to non- implementers of Six Sigma. The case study analysis revealed improvement on the softer issues in Six Sigma firms such as customer satisfaction, employee satisfaction, employee empowerment, fact-based decision making, focus on education and training, and developing in-house skills to sustain the Six Sigma initiative in the firm The improvement in performance of ISO certified firms were attributed to management proximity to customers and quickly addressing their complaints rather than as a result as of ISO 9000 certification. The characteristics and attributes of Six Sigma, as discussed in Chapter 3, makes it different from other CI initiatives like TQM when implemented in organizations (Snee, 2004; Antony, 2009; Kumar *et al.,* 2008), provided there is strong leadership and management commitment. The improvement in performance of the Six Sigma firms may also be attributed to frequent use of quality tools and techniques for problem solving as compared to the non-Six Sigma SMEs.

***RQ5:** How to assess the readiness of a SME to embark on Six Sigma journey?*

The Six Sigma readiness index was constructed by reviewing the CI maturity models literature (Kaye and Dyason, 1995; Lascelles and Dale, 1991; Dale and Lascelles, 1997; Dale and Smith, 1997; Dale *et al*., 1997; Bessant and Caffyn, 1997; Bessant *et al*., 2001) and matching it against the key findings from the multiple-case studies. The Readiness index would assess an organization's preparedness to embark on Six Sigma journey based on its score against the five criteria of the index. It investigates the past quality management practices of participating firms to assess their future capability to embark on the Six Sigma journey. Readiness assessment would ensure successful implementation of Six Sigma in SMEs without any major disruption. The readiness index was tested in three firms to check its ability to measure the items/ factors for which it was designed. The scores of the three firms matched with their existing quality management practices, thus indicating the validity of the index designed. However, this index requires testing in several industries, and with academics and practitioners to further test its measurement validity and robustness. The index was novel contribution to this doctoral thesis that may help SMEs assess their preparedness for Six Sigma implementation.

Addressing the aforementioned research questions facilitated in understanding of the status of Six Sigma implementation in the UK SMEs and designing a customized five phase Six Sigma framework tailored to the needs of SMEs. The framework was designed by evaluating and including the key findings from the RQ1-RQ5 in the five phases of the framework. SMEs passing the Six Sigma readiness test are ready to embark on Six Sigma journey using the proposed framework. SMEs adherence to the framework may facilitate successful implementation of Six Sigma as well as sustaining its benefits on a long-term basis. The framework will be tested in future to gauge its feasibility and ease of implementation in a SME environment. This was another major contribution to this doctoral work.

10.2. Quality of Research

In order to ensure that research is fully completed, it is not only important to answer the research questions but also to ensure that high quality research standards are achieved in several aspects of this research against the set criteria (as discussed in Section 5.3 and table 5.11). This section includes discussion on how the quality criteria of reliability and validity were enhanced (Easterby-Smith *et al*., 2002; Yin, 2003; Voss *et al*., 2003) and contribution made to the Six Sigma body of knowledge and practice. The summary of quality criteria for this research is presented in table 10.1. Here, reliability refers to "*the extent to which your data collection techniques or analysis procedures will yield consistent findings*" (Easterby-Smith *et al*., 2002), while validity refers to the issue of whether the set of indicators *"devised to gauge a concept really measures that concept"* (Bryman and Bell, 2007).

Table 10.1: Quality criteria for this doctoral research

Quality Criteria	Criteria addressed in this research	Criteria fulfilled YES/ NO
Reliability	*Survey*: Adaption and use of survey instrument from previous research *Case study*: Use of Interview protocol, case documentation and review, database generation	**YES**

Construct Validity	*Survey:* NA *Case Study:* use of multiple sources of evidence, e.g. interviews, company annual report, brochures, newsletter, and presentations Case study report reviewed by interviewees and feedback received was incorporated in the report	**YES**
Internal/ Content Validity	*Survey:* Used the literature to design the questionnaire and incorporated experts' comments to revise instrument *Case Study:* NA	**YES**
External / Criterion Validity	*Survey:* Being tested to make accurate predictions of performance of two groups, i.e. Six Sigma and non-Six Sigma SMEs, against nine performance metrics *Case Study:* Multiple case-studies conducted in two clusters, i.e. Six Sigma and non-Six Sigma SMEs. Use of polar cases in each cluster to achieve theoretical sampling	**YES**
Contribution to theory	Novelty of research and 'value-addition' to what is already known in the literature	**YES**
Contribution to practice	The implications and conclusions from the research that can be used by other researchers, policy makers, or practitioners to make decision for their processes, business or other social issues	**YES**

10.2.1. Research Quality criteria for Survey Research

Reliability analysis (internal consistency analysis, i.e. Cronbach's alpha test) was not conducted for the survey instrument due to the limited number of multi-item questions in the instrument. However, reliability of the instrument was ensured through adaption and use of the questionnaire from previous research (Antony *et al*., 2007; 2007; Kumar, 2007). The adaptation ensured that the instrument will produce consistent findings when tested in different conditions (Saunders *et al*., 2007). *Content validity* measures the extent to which the content of the items in a summated scale truly measures the concept it intends to measure (Malhotra and Grover, 1998). This was achieved by reference to the literature and experts well versed in the domain. The author used the literature to design the questionnaire and incorporated experts' comments to ensure the content validity. The most common validation in survey research is the *construct validity* that measures whether the set of items constituting a measure is an appropriate operational definition of the theoretical construct measured (Flynn *et al*., 1990). Construct validity is not required to be tested when the survey instrument does not use multiple-item measurement scales (Rungtusanatham *et al*., 2003). Thus, the construct validity test was not required in the author's research project due to the *limited number of multi-item questions in the survey instrument.* The *criterion-related validity* refers to the ability of the scale to investigate the relationship between predictor variables and the external variable (objective outcome or criterion). The *criterion-related validity* is established when the measure differentiates individuals on a criterion it is expected to predict (Nunnally, 1978; Forza, 2002; Saunders *et al*., 2007). In this study, the author was interested in comparing the similarity / differences in the performance of Six Sigma and non-Six Sigma firms against nine performance metrics established from the literature, criterion-related validity was being tested to make accurate predictions of the performance of two groups, i.e. Six Sigma and non-Six Sigma SMEs. Flynn *et al* (1990) suggests the use to summated scales from the past research with established validity and reliability to counteract with the difficultly of establishing validity and reliability in the new research.

10.2.2. Research Quality criteria for Case Study Research

In case study, *reliability* is ensured by designing a case-study protocol and developing a case study database so that data collection procedures can be repeated with similar results when another investigator repeats the study (Yin, 2003; Easterby-Smith *et al.*, 2002). Interview protocol and case study databases/ reports were developed to ensure the reliability of this doctoral research. Moreover qualitative data was analyzed using tables, figures, and a 2 x 2 matrix to ensure similar interpretation of the key findings from the case study. *Construct validity* was achieved in this research through use of multiple sources of evidence using semi-structured interviews with senior / middle management teams at company sites, non-participant observations during visits, documentation (company annual report, brochures, newsletter, and presentations) and getting the consent from interviewees on the contents of the company report created from interview process. *Internal validity* was not considered in this study due to the exploratory nature of the study in which no attempt was made to establish the causal relationship between variables, which is more focused in an *explanatory case study*. *External validity* refers to generalization of a study's findings beyond the immediate case study (Yin, 2003, Easterby-Smith *et al*. 2002; Voss *et al*., 2003). While exploring or building theory from case study, replication logic rather than sampling logic is used to predict either similar results [literal replication] or dichotomous results for predictable reasons [theoretical replication] (Voss *et al*.,2002; Eisenhardt, 1989; Miles and Huberman, 1994). Thus the case study focuses more on *analytical/theoretical generalization* (as compared to survey, where statistical generalization is the preferred path) and research is striving to generalize a particular set of findings to a broader theory. Multiple case studies were conducted (using the concept of theoretical sampling) in Six Sigma and Non-Six Sigma SMEs to establish the external validity (theoretical generalization) for this research. Multiple case studies of the participating firms included polar cases in both cluster- Six Sigma and non-Six Sigma firms, to achieve the concept of theoretical sampling (Eisenhardt, 1989).

10.2.3. Contribution to theory/ knowledge

A researcher is expected, in the domain of their research area, to contribute to the theory/knowledge in terms of novelty of research and 'adding value' to what is already known in the literature. The researcher can make a contribution to knowledge in the following ways (Ates, 2008) by: confirming to existing theories; extending existing theory into new areas; advances in methodology; development in the application of techniques; generating hypotheses, grounded theory, or insights; rejecting null-hypotheses and accepting alternate-hypotheses, to name a few. This research adopted a mixed method approach to contribute to the advancement in methodology application within the Six Sigma research in SMEs. The author had made a contribution to theory by answering the five research questions established at the outset of this research and developing a better understanding and know-how of a less explored research area of '*Six Sigma for the Little Guy*'.

The Six Sigma body of knowledge was enriched through the following contributions from this research:

- This research demystifies the prevalent myth in Six Sigma literature that Six Sigma can only be implemented in large organizations. The empirical research had clearly demonstrated successful implementation of Six Sigma in SMEs of sizes ranging from 35 to 240 headcount.
- The research developed better understanding of differences in characteristics between SMEs and large organizations with respect to quality management practices by combining the literature of growth of small firms with quality management (**RQ1**). This is among very few instances when researchers have linked the literature on small business growth models to quality management practices in SMEs.
- Better understanding of quality management practices of SMEs was developed by comparing and contrasting the similarities/differences in QM practices of Six Sigma and non-Six Sigma SMEs (**RQ2**). Some similarities as well as polar results were observed while comparing the QM practices across the two clusters. The research also indicated that ISO or similar systems may be the foundation or building block to embark on the Six Sigma journey.
- The CSFs study clearly indicated that all CSFs are equally important for organizations to embark on the CI journey and is independent of type of CI initiatives or certification systems undertaken by firms, i.e. factors identified as critical for the Six Sigma firms are equally important for the non-Six Sigma firms (**RQ3**). Networking and role of middle managers were the two new CSFs that emerged from this empirical research.
- Better understanding of challenges faced by SMEs while embarking on the CI journey of Six Sigma or Lean and introspection on how to overcome such barriers (**RQ3**).
- The research clearly demonstrated the differences in performance of Six Sigma and non-Six Sigma SMEs and explicated its link to existing QM practices in the respective organizations (**RQ4**). Six Sigma SMEs outperformed non-Six Sigma firms against the established criteria to measure the success of program.
- Development of criteria, based on empirical research and literature review, to assess whether a SME is ready to embark on Six Sigma journey, i.e. assessing organizational preparedness for Six Sigma (**RQ5**). Criteria developed to

measure Six Sigma readiness index was further tested in sample firms to assess the validity of the instrument.

10.2.4. Contribution to practice

The implications and conclusions from the research that can be used by other researchers, policy makers, or practitioners to make decisions for their processes, business or other social issues is referred as *contribution to practice*. The researcher can make a contribution either by developing frameworks, models, guidelines, road maps, policy or provide suggestions for changes/improvements related to business or other social issues.

The practical contributions made by this research are listed below:

- ***Development of a valid and novel Six Sigma Readiness Index*** to assess organizational preparedness for smoother implementation of Six Sigma without causing any major disruption during the deployment process.
- ***Improved understanding of the key ingredients required by SMEs*** before embarking on the Six Sigma journey
- ***Development of a novel and practical Six Sigma framework****,* customized to the needs of SMEs, to facilitate implementation and long-term sustainability of benefits realised from Six Sigma.
- ***Readiness assessment is the prerequisite for SMEs*** to fulfil before starting to use the customized Six Sigma framework to facilitate its implementation
- ***Lean may be used for the first round of improvement*** in SMEs before embarking on Six Sigma as it facilitates a quick win and results are very visual
- ***Improved understanding*** among SMEs in reference to the ***relationship between Six Sigma implementation and organizational performance***.
- The research clearly indicated the ***role played by government funded bodies such as MAS and MI, and academic institutions*** in facilitating knowledge transfer of best-in-class practices of CI initiatives such as Lean and Six Sigma. Government bodies should take requisite measures to communicate the different types of funding available for SMEs and other supports they can seek

from institutions such as MAS. Current awareness of the existence of such organizations and the type of support provided is unclear to SMEs. Formation of Six Sigma user groups for SMEs, funded by government, may help in raising awareness and sharing of best practices among SMEs by conducting regular events, conferences, workshops and seminars on CI.

The key contributions of this research that makes it different from the previous research work or literature were summarised in table 10.2.

Table 10.2: The novel contributions of this doctoral research

Research Questions	Novel Contributions*
RQ1: *What makes SMEs different from large organizations?*	▪ Identified the differences between two clusters by reviewing the literature on the small business growth models and combining it with findings from the QM literature. ▪ This is among very few studies in QM literature that presents the difference in characteristics of SMEs through the lens of small business growth models. ▪ Also made an attempt to understand the maturity of a firm on a CI journey by reflecting on the growth models of small businesses
RQ2: *What are the critical differences in quality management practices of Six Sigma and non-Six Sigma SMEs?*	Many key findings were similar to that proposed in literature; the novelty lies in the identification of following: ▪ ISO certification is beneficial for SMEs provided they follow it religiously ▪ ISO foundation to embark on the CI journey of Lean and Six Sigma (in literature, this proposition was not clearly stated) ▪ Lean is good for first round of improvements in SMEs as it provides quick win and breaks down the resistance to change- gives a platform to embark on Six Sigma ▪ The involvement of accounting and finance departments was identified as critical in the quantification of benefits generated from the Six Sigma projects ▪ To have minimal effect of scare resource, rotation policy of BBs and other employee involved in Six Sigma project to build a sustainable organizational infrastructure in SMEs; also suggested train the trainer approach to build their human capital on Six Sigma
RQ3: *What are the critical success factors and barriers to implementation of Six Sigma in SMEs?*	Key findings in this section was similar to literature on CSFs & challenges, except the following ▪ Networking and role of the middle managers identified as two new factors emerging from this study; ▪ Past literature on QM had limited discussion on the role played by government bodies or academic institutions in driving change in a SME environment ▪ Resource constraint is an excuse for senior management

	in SMES not to implement Six Sigma; If a firm with 36 employees can implement Six Sigma successfully, it is feasible to implement in other small or medium-sized enterprises
RQ4: *Does the performance of Six Sigma firms differ from non-Six Sigma firms?*	▪ No literature in the past compared the similarities/differences in performance of SSS and NSSS (past literature focused on comparing performance of TQM adopter and non-TQM adopter SMEs) ▪ The link of Six Sigma project to bottom-line savings was clearly demonstrated from the case study findings- focus of TQM literature on this aspect was limited
RQ5: *How to assess the readiness of a SME to embark on Six Sigma journey?*	▪ Proposed a Six Sigma Readiness index; Past literature is devoid of any readiness index that assesses SMEs preparedness for TQM, Lean or Six Sigma Journey ▪ Also answering the RQ1-RQ5 led to the development of a practical customized framework for Six Sigma implementation in SMEs; the literature is devoid of any such Six Sigma framework proposed for the use of SMEs

**Compared the research findings against the work of Shea and Gobeli (1995);Yusof and Aspinwall (1999, 2000a, b, c); Ghobadian and Gallear (1996, 1997); Lee (1998, 2004);Rahman (2001a,b); Wessel and Burcher (2004); Antony et al* (2005, 2008); Achanga *et al* (2006)

10.3. Agenda for future research

10.3.1. Limitations of the research

This research focused only on UK manufacturing enterprises to assess the current status of Six Sigma implementation in SMEs. The response rate from the first phase of the study, i.e. survey, was low (12.8%) and a limited number of respondents were applying Six Sigma (15.6%). SMEs implementing Six Sigma were at very early stages of implementation (3-4 years of experience) and thus reflection on improvement in performance metrics was not fully realised. The second phase of research involved multiple case studies in 10 firms and 24 interviews with the senior/middle management teams in these firms. As this was among the very few studies on Six Sigma implementation in SMEs, the author decided to conduct exploratory research to let the theme and findings evolve from the study. The focus of the study was not to establish causal relationships between variables involved in the case study. No attempt was made to compare the findings from this research with large organizations implementing Six Sigma. Due to time and financial constraints, it was difficult to revisit the participating firms more than two times in the second phase of research. Any queries were dealt through telephonic conversations with participants in the case study. Design of the Six Sigma Readiness Index and framework was based on the key findings from the small sample and matching it with the literature. Both the framework and index were only tested in 3 SMEs for its robustness and validity. All the aforementioned facts may limit the statistical generalizability of the findings.

10.3.2. Future research directions

The author, from his experience, holds a belief that until you sail through an arduous task, you can't comment on how you could have done this work differently or how you could improve this work in future. Just as quality is a CI journey, the whole PhD process and outputs produced also requires further refinement or improvement. The aforementioned paragraph introduced some of the limitations of this doctoral research, which could be improved in future to make the findings more generalizable to the larger population. Some of the possible ways to address the generalizability issue are listed below:

1. Increasing the scope of Six Sigma research in SMEs by including service firms as well SMEs from across Europe and other continents. This will provide a better picture of the status of Six Sigma implementation in SMEs across the globe. This may also facilitate in identifying whether the culture of a country has any impact on the success of Six Sigma.
2. The survey and case study research should also include large organizations to do a comparative analysis of differences in QM practices of SMEs against their larger counterparts

   Proposition that could be tested based on aforementioned statement is

   Proposition 1: *QM practices in firms implementing Six Sigma is independent of the size of the firm*

3. This study can act as a base to conduct further *explanatory research* to statistically establish the causal relationship between CI initiatives, QM practices, and organizational performance of SMEs

   The aforementioned statement leads to following proposition:

Proposition 2a: *There exists a causal relationship between the implementation of CI initiatives like Lean/ Six Sigma and organizational performance*

Proposition 2b: *There exists a causal relationship between quality management practices and organizational performance, with CI initiatives like Lean/Six Sigma acting as the mediating factor*

4. Future research should also explore the relationship between ISO certification and Six Sigma implementation, as this research has given an indication of ISO being base or building block to embark on the Six Sigma journey

   The aforementioned statement leads to following proposition:

   Proposition 3: *Good Quality Management System can act as a building block to embark on the Six Sigma journey*

5. The knowledge, usage, and usefulness of tools and techniques of CI and its impact on performance of SMEs needs further exploration

   The link between tools usage and performance leads to following proposition:

   Proposition 4: *There exists a causal relationship between usage of tools / and techniques of CI and organizational performance*

6. This research did not focus on establishing the organizational infrastructure for Six Sigma implementation in SMEs, i.e. number of Black Belts (BB), Green Belts, and Yellow Belts required in SME environment. There exists a rule of thumb for large organizations, i.e. for every 100 employees, you can have 1BB, and 10 GB. Future research may also focus on whether SMEs need Black Belt for project execution as it requires significant initial investment

   Following proposition is deduced from aforementioned statement

   Proposition 5a: *The number of Black Belts and Green Belts required in a SME environment is different from that required in large organizations*

Proposition 5b: *Black Belt is not required in SMEs to conduct Six Sigma projects*

7. The savings generated from the BB and the GB project in a SME environment is different from that generated in large organizations. This could be another area for further exploration to establish the right figure for project savings generated from a BB project in a SME

   Saving from Six Sigma projects in SMEs leads to following proposition

   Proposition 6: *The savings generated from Black Belt and Green Belt project in SMEs is different from that in large organizations*

10.4. Critical Reflection

About 20 years have passed since the birth of Six Sigma in Motorola. Now the important question is “Is Six Sigma sustainable in the 21st century? How long?”. I believe that Six Sigma is sustainable, and will last for a long time. The answer to the question “Is Six Sigma a passing fad?” is clearly no. Six Sigma is neither a fad nor just another quality initiative. It is a ‘way of life’. It is a business strategy based on objective decision making and problem solving, relying on meaningful and real data to create actionable goals, analyzing root cause(s) of defects, and thus suggesting the ways to eliminate the gap between existing performance and the desired level of performance.

Six Sigma will keep on building its momentum in almost all types of industries, irrespective of the size and turnover, with no signs of giving up in the immediate future. The challenge for all organisations is to integrate Six Sigma into their core business processes and operations rather than managing it as a separate initiative. In author’s opinion, Six Sigma will continue to grow as a powerful management initiative for achieving and sustaining operational and service excellence. It might evolve into a ‘new package’ when it fails to achieve significant returns to the bottom-line. However, the sound principles and key concepts of Six Sigma will stay with it for many years (Snee, 2004, Antony, 2008a). In future, the Six Sigma toolkit will be enriched by the continuous emergence of new useful tools and techniques, especially in the software, finance and healthcare applications. I believe that organisations developing and implementing Six Sigma strategy should not view it as an advertising banner for promotional purposes.

Some of the emerging research trends of Six Sigma include: integration of Six Sigma with Lean Manufacturing, Agile Manufacturing, Quick Response Manufacturing, and Theory of Constraints; development in new application areas such as healthcare, finance, sales, human resources, software engineering; integration of Six Sigma with other quality improvement initiatives such as ISO 9001:2008, and EFQM Excellence Model; selection of Design for Six Sigma (DFSS) strategy over Six Sigma – based on a number of variables such as risk, technology, customer demands, time, cost and complexity; tailoring the existing Six Sigma DMAIC methodology for SMEs; the relationship between Six Sigma and organisational culture and learning; integration of eco-effective design into the DFSS processes to foster healthy and prosperous conditions for humans and ecological systems by reusing materials and components in natural biological or technical cycles; integration of DFSS with lean thinking, may be called as 'Design for Lean Sigma'. One of the areas that need further exploration is the relationship between Six Sigma and innovation. Does Six Sigma facilitate innovation or hamper innovation by following a structured and disciplined approach? How do DFSS foster innovation compared to Six Sigma? Very limited research has been done to date on relationship between Six Sigma and innovation. This is a very promising area of research that needs further exploration.

Though Six Sigma is a well established quality management program that had resulted in dramatic improvement in the bottom-line savings, its application in the UK large organizations is not prevalent. What chance do their supply chain partners (in most cases are SMEs) have to be aware of or implement Six Sigma? Six Sigma had helped many companies appearing in the Fortune 500 list to improve their process efficiency and effectiveness. It is now considered as a management philosophy in many world-class companies that had changed the thinking process of employees in these companies. I was involved in organizing 6-7 conferences and workshops on Six Sigma in the UK in the last five years. It was shocking to see the minimal participation of the UK industry and academic fraternity in the conference/workshop as compared to the delegates coming from the USA (where Six Sigma was born in Motorola) and other European countries. More than 70% of the delegates in the aforementioned conferences were from the USA. This shows the commitment of the USA counterpart in the CI journey as compared to the UK.

I have often heard people giving the excuse that Six Sigma is more Americanised and so it is not applicable within the UK context. I am not sure if such an excuse is acceptable, especially when the UK industry is facing stiff challenge from the low cost South Asian economy. In my experience, the main reasons for low implementation of Six Sigma in the UK are as follows: Six Sigma involves many statistical tools and techniques, which many process engineers/quality managers/ operation directors in the UK are not comfortable to use for process improvement. This problem keeps on appearing in the news and tabloid press that the UK schools are struggling to find good teachers in Maths and Statistics. In many Business School across the UK, statistics and mathematics calculations are kept to a minimum in the programs offered to students. What chances do we have to improve our skills, if we don't get the basics right at the School and the University level? I don't blame SMEs for not implementing initiatives like Six Sigma as they are not pressurised by their OEMs to do so. Lean is more popular in the UK SMEs compared to Six Sigma as it involves visual tools and techniques that can be comprehended by any layman.

As witnessed from the case study analysis, SMEs that have implemented Six Sigma without taking a cutting corner approach (e.g. *A, B, C,* and *E*) have reaped significant benefits both in the hard and soft performance metrics. Few sample firms were lucky to get support from their OEMs or parent company, or academic institutions, or government bodies like MAS, SMAS, and MI. The question is how many SMEs are lucky to get that support or are aware of such support system existing? Here the role of academic institutions, government bodies, and OEMs are very crucial in raising the awareness of CI initiatives and facilitating SMEs to implement such initiatives. Government bodies like SMAS, MAS, and MI were formed to help the UK SMEs in improving their process efficiency and effectiveness. The initial diagnostic services provided by consultants, working for the government bodies, are free for SMEs and thereafter they offer services at much subsidised rate. These bodies try to help those SMEs who approach them to discuss their quality or process related issues or have expressed some interest in the CI initiative(s).

Similarly academic institutions offer support to SMEs through the KTP program to resolve their operational problems in the firm. The SMEs approaching government bodies or academic institutions are aware of such support systems and are also very keen to improve their operational efficiency. Out of 4.5 million enterprises in the UK (DTI, 2006), 99.9% are SMEs. How many of these SMEs are aware of such support provided by government and academics? Hardly 1-2% of the SMEs population are aware of the opportunities to collaborate or network with government bodies and academic institutions. I think there should be some changes in government policies (in redefining the roles and responsibilities of bodies like MAS and MI) and requires active involvement of academics in the UK (by organizing more conferences, seminars, and workshops on CI initiatives). This would raise awareness of the support available for SMEs to improve their operational efficiency and effectiveness. Very few universities (5-6) in the UK are involved in Six Sigma research and offering training support to SMEs or larger organizations. I think the UK is 10 years behind in terms of knowledge and application of CI initiatives compared to the USA. Academic institution and government bodies have got a huge role to play here in making the UK manufacturing and service industry globally competitive.

From the research design perspective, I have witnessed that many PhD students stick to one paradigm (either positivist or phenomenological paradigm) while researching an operations management topic. The analysis of articles published in two of the best journals in the area of Operations Management (Journal of Operations Management [4*] and International Journal of Operations and Production Management [3*]) indicated that majority of academics and research students in USA takes a positivist stance compared to phenomenological stance taken by their UK counterpart. The reasons stated by some researchers such as Meredith (1998), Boyer and Swink (2008) and my own comprehension indicates that researchers don’t want to leave their comfort zone. The decisions to choose the research paradigm were largely influenced by their previous experience of using the qualitative or quantitative approaches to their research problems. However, the choice of paradigm should be based on the type of research questions established at the start. I am very quantitative person and enjoy playing with numbers. I should have only used positivist paradigm to finish my doctoral research. However, I chose to use a mixed method approach of positivist and phenomenological paradigm to address my research questions. As Six Sigma in SMEs is a new and developing area of research with limited theoretical knowledge about its application within SMEs context, it was rational to use a mixed method approach so that the new theory is generated and tested in the sample firms. It was clearly stated in Chapter 4 and Chapter 5 that mixed methods minimizes the limitation of individual approach to research and is therefore beneficial in getting enriched information on a phenomenon of interest. However, I am afraid that mixed method approach is not popular in the UK doctoral research. I think it would be wrong to blame only Doctoral students for this choice. Their supervisors or Director of Studies have huge role to play in deciding the choice of philosophical paradigm. Similar to students, Director of Studies (in most cases) also don't want to leave their comfort zone and thus stick to one paradigm which they are very comfortable with. I hope this approach to research would change in future by raising more awareness of mixed methods in operations management conferences, and publication of more articles on mixed methods in the best journals of operations management.

The author had presented and published key findings from this research in some International conferences and peer reviewed journals, the details of which are listed in Appendix V.

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Appendices

Appendix I: Growth models of SMEs

Appendix II: Survey Questionnaire

Appendix III: Invitation letter and interview protocol

Appendix IV: Six Sigma Readiness Index questionnaire

Appendix V: List of publications from this doctoral research

APPENDIX I

Growth Model of SMEs

Business researchers have proposed a number of models over the last five decades that seek to delineate life cycle of small business. Dobbs and Hamilton (2007) classified the approaches to study the life cycle of small business into six broad categories: stochastic; descriptive; evolutionary; resource-based; learning; and deterministic. For the purpose of this research, the review is limited to only three approaches, i.e. *descriptive, deterministic and learning approaches,* to identify and understand the critical factors affecting the transition of small firms into large organization, rather than understanding 'how' the transition occurs in all the categories discussed by Dobbs and Hamilton (2007). Moreover, the other three approaches, i.e. *stochastic, evolutionary, and resource-based*, have several limitations and failed to explain and justify the phenomenon of small business growth (Levie and Hay, 1998; Vinnell and Hamilton, 1999; Rutherford *et al*., 2003; Reichstein and Dahl, 2004). The identification of critical factors and their impact on small business growth are measured by focusing only on the key approaches: *descriptive, deterministic and learning approaches*. The focus of reviewing the growth models is only to understand the key characteristics of firms rather than commenting on how the firm transform from small business to large organization.

Descriptive approach

SMEs in the past have failed to realise that their future success lie in understanding the characteristics of their own business and its evolving stages of development. The main tenet of 'descriptive' research perspective is underpinned in two significant assumptions: firms grow linearly; and this growth can be categorised into predictable, discrete, and consistent stages (Lippitt and Schmidt, 1967; Steinmetz, 1969; Greiner, 1972, 1998; Churchill and Lewis, 1983; Quinn and Cameron, 1983; Scott and Bruce, 1987). Moreover, each stage or phase is both an effect of the previous phase and a cause of the next (Greiner, 1972, 1998). The transition from one phase to next requires considerable changes and often experiences crisis (Steinmetz, 1969; Churchill and Lewis, 1983; Scott and Bruce, 1987) or revolution (Greiner, 1972,1998) followed by stability. The models proposed by researchers act as diagnostic tools in assisting firm's current position and a indicator of strategies that would be suitable at different stages of firm growth. The focus in this section is to identify the critical factors that facilitate in trouncing the crisis as the firm progresses to next stage in its life cycle.

To develop the better understanding of the stage model, we will discuss the work of Greiner (1972), as this is the most cited literature on stages of small business growth. Greiner (1972, 1998) considered five key dimensions of age; size; stages of evolution; stages of revolution; and growth rate of industry, to build a *general growth model* for organization development as presented in figure 1 and table 1. Greiner (1972) described the growth stages of firms as 'evolution' [i.e. describe the prolonged periods of growth whereon major upheaval occurs in organization practices] and the critical transition stage to next phase as 'revolution' [i.e. describe those periods of substantial turmoil in organization life]. The model reflects the change in management style from individualistic and entrepreneurial to participative as the firm matures and grows bigger.

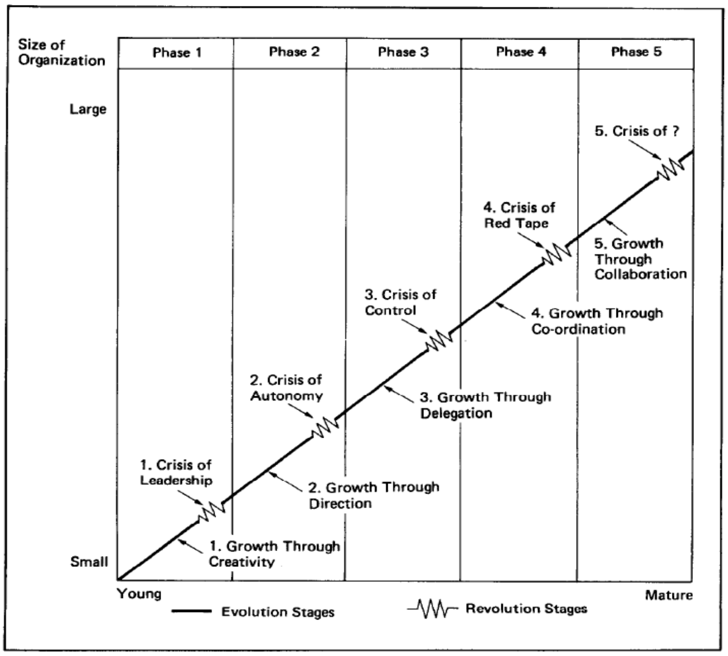

Figure 1. Greiner model of five stages of growth (Greiner, 1972)

Revisiting the topic again in 1998 and studying number of firms, Greiner stated that that major phases of development in the life of growing companies last between three to fifteen years each. The high growth industry experiences each phase at a faster rate as compared to slow-growing industry. The organizational practices during the five phase of growth in Greiner's model are presented in table 1 below. Strong leadership, management commitment and focus, formal organizational structure, and reward and recognition were considered as critical factors in the growth of small firms.

As a firm grow from small size (Phase 1) to large organization (Phase 5), as shown in figure 1 and table 1, significant changes in organizational structure, management style, control system, management focus is observed. During this transition period, the structure becomes more formal, management becomes participative in delegating responsibilities and more focus is on expanding the market and consolidating their business rather than struggling for survival. As the firm grow, more resources are available (human, technical, financial) to train and reward employees, that may result in the improvement of established strategic and operational performance measures. These observations are also reported in other literature on the life cycle of small business (Lippitt and Schmidt, 1967; Steinmetz, 1969; Greiner, 1972, 1998; Churchill and Lewis, 1983; Quinn and Cameron, 1983; Scott and Bruce, 1987; Mitra and Pingali, 1999; Shim *et al*., 2000; Kazanjian, 1988; Gupta and Chin, 1993; Hanks *et al*., 1993; Barringer *et al*., 2005).

Table 1. Organizational Practice in the five phases of growth (Greiner, 1972)

Category	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Management Focus	Make and Sell	Efficiency of operations	Expansions of market	Consolidation of organization	Problem Solving and innovation
Organizational Structure	Informal	Centralized and functional	Decentralized and geographical	Line staff and product groups	Matrix of teams

Top-Management Style	Individualistic and entrepreneurial	Directive	Delegation	Watchdog	Participative
Control System	Market results	Standards and cost centres	Reports and profit centres	Plans and investment centres	Mutual goal setting
Management Reward Emphasis	Ownership	Salary and merit increases	Individual bonus	Profit sharing and stock options	Team Bonus

An imbalance of aforementioned factors at each stage of growth may result in creating serious problems for the entrepreneur. It is therefore vital for the managing directors of small businesses to understand, anticipate and manage the factors as they become important to the company. The knowledge of their current status would facilitate managers to make more informed choices and get prepared themselves for future challenges. Similarly, analyzing other literature on stage models for organizations facilitated in identifying critical factors that determines the successful growth of small firms. The details of the findings are presented in table 2.4. Concluding from the review of descriptive stage models, determinants of small business growth are as follows: Strong Leadership; Management Commitment; Strategic Planning; Formal organizational structure; Focus on human resources; Information planning and control mechanism; Flexibility.

Stage models proposed in the past have received criticism in recent years for being conceptual, descriptive (Phelps *et al*, 2007; Bessant *et al*., 2005), speculatively normative (Gibb and Davies, 1990), and prescriptive in assuming that all firms grow through series of predictable phases or preordained stages. Stubbart and Smalley (1999) argues that stage models are enticing because of simplification of several facts associated with complex transformational change to a uniform, predictable, unidirectional, designated liner paths. Majority of the proposed descriptive stage models is either theoretical or conceptual in nature or grounded in empirical model of questionable validity.

Business models proposed by the researchers in the past for small businesses experience stages of growth, each with its own distinctive characteristics. It's true that not all business experience all phases of growth. However, a prior knowledge of next stage of development would facilitate the owner in planning the future of the business.

These models may help the SMEs to identify the crisis point in the growth stage and identify the remedial measures that would be necessary to successfully negotiate the next stage of growth. Some of the other information drawn from models is presented below.

- Few organizations experience all the phases of growth. Most of the companies fail in the initial phase of inception and survival or often merges/get acquired by companies that are in a stage of growth or maturity.
- Each phase of business growth posses its own characteristics, unique structure, systems, and leadership. The strengths and learning from the preceding phase will add on to or act as essential for the success in succeeding phase.
- Business models proposed provides a simple outline of the vast challenges the management may encounter when envisaging the firm growth- e.g., challenges

during the change of role from direct supervision in the start stage to delegation of responsibilities as the firm grow larger.

- Being cognizant about the history of business development would enable the managers to be in a vantage of evaluating their current status, predicting problems, dismantle current structure, proactively prepare solution and coping strategies for problems.

One of the criticisms of descriptive stage models is that researchers failed to statistically validate models and explain the variation in critical factors at different stages of firm's growth. However, as cited in majority of stage models literature, the performance of any organization still depends on fundamentals of goal management – strong leadership, committed and motivated workforce, understanding voice of customer and devising a winning strategy.

Deterministic approach

Similar to descriptive approach, *deterministic approach* also focuses on life-cycle models for business to grow. The critical difference in two approaches lie in the fact that the *deterministic approach* takes into account set of explanatory variables relating to people, firm, and its industry environment to explain the variation in the organization growth rates by applying the concept of multivariate techniques to large cross-section data sets (Dobbs and Hamilton, 2007). On the contrary, there is no statistical rigour involved in validating the models of small business growth in descriptive approach.

The research in this dominant empirical approach to develop the prescriptive model of small business growth is growing in importance to establish the list of context-specific variables that determines the growth of small firms (Barringer *et al*., 2005; Davidsson and Klofsten, 2003; Chaganti *et al*., 2002; Shim *et al*., 2000; Mitra and Pingali, 1999; Hanks and Chandler, 1994; Hanks *et al*., 1993; Kazanjian, 1988; Smith *et al*., 1985). Most of the models proposed were developed by taking cue from the work of Greiner (1972), Churchill and Lewis (1983), and Scott and Bruce (1987).

Sample cases selected during model development in many studies were associated with high technology companies or newly formed companies (Kazanjian and Drazin, 1989). Majority of the listed researchers used factor analysis followed by cluster analysis to determine the existence of discrete life cycle stages through identification of patterns of variables. The focus was on how the variables vary across different stages of life cycle, i.e. a variable may be important when the firm is at its inception but the degree of importance will change as the firm matures into large organization. For example, at the inception stage, more importance is given to autocratic style of leadership whereas the importance shifts to participative style as the firm matures. Similarly the organizational structure is centralised and informal during the start-up stage but more importance is assigned to formal structure to manage the business in a better way as the firm matures.

Several factors critical to the growth of firms were identified and is listed in table 2.5 below. *Organizational structure, planning, communication, strategy, top-management decision making, management style, resources, rewards, organizational size and age* are some common factors emerging from the review process.

More emphasis is given in high-growth industry to mission statement, commitment to growth, customer knowledge, business strategy, and human resources issues such as employee training and education, and financial incentives as compared to slow-growth counterparts. *However, many researchers failed to prioritize or provide ranking to factors that are important in life-cycle of a firm through statistical analysis. Future work need to empirically validate the importance of each factor at different stages of firm growth.*

APPENDIX II

Strathclyde Institute of Operations Management
Design Manufacturing and Engineering Management
University of Strathclyde

Survey Questionnaire

In the attention of General Manager/ Quality Manager/ Operations Director

Dear Sir/ Madam

The Strathclyde Institute of Operations Management at University of Strathclyde is ***conducting a survey as a part of a Doctoral study to assess the status of UK Small and Medium-Sized Enterprises (SMEs) in implementing quality improvement initiatives within their unit*** to enhance customer satisfaction and bottom-line impact. The Strathclyde Institute for Operations Management brings together the leading experts in Operations Management from Strathclyde Business School and Engineering Faculty to establish Operations Management as a strategic resource. The mission of the Institute is to provide thought leadership and facilitate the advancement of the theory and practice of operations management through internationally leading research, innovative education programmes, and services to business.

The main aim of this Doctoral research is to develop a **'Readiness Index'** that can identify key areas a company is excelling in or indeed if underperforming. We plan to develop a **practical framework for SMEs** as a guide to getting started with quality improvement initiatives like Lean and Six Sigma and in achieving and sustaining results. The results from the survey will be used for the research purpose only and no attempt will be made to identify any individual in the organisation. All responses will be treated with the utmost confidence and no single set of responses will be readily identifiable. Your assistance and time taken to complete this questionnaire is greatly appreciated. **Companies participating in this study will be offered a discount of 10% to attend the "First European research conference on quality management and Lean Six Sigma" in Glasgow. For more information about the conference, please visit http://www.inderscience.com/mapper.php?id=51 .**

Thanks a lot

Kind Regards

Maneesh Kumar
M103, James Weir Building
75 Montrose Street
University of Strathclyde
Glasgow- G1 1XJ
Email: maneesh.kumar@strath.ac.uk
Voice: 0141 548 2588 (o), 07727008427 (m)
Fax: 0141 552 0557

Quality Improvement Initiatives within UK Small and Medium-Sized Enterprises: A Survey

The attached questionnaire is designed to assess the status of quality improvement initiatives within the UK SMEs. I would appreciate if you could help me by responding to the attached questionnaire. There are no right and wrong answers as we are trying to establish the current practices within SMEs. The questionnaire will take about 5-10 minutes to complete. The survey will be analysed on a collective basis and data will be analysed as per the research objectives established at the beginning of the research. I would be happy to share the results of my study, if you provide me with your contact details. Thank You in advance for your help. I appreciate your support and help.

Part I Company Background

This section asks for some background details of yourself and your organisation.

1) Name of organisation and start up year:

____

2) Type of Firm

☐ Local Firm ☐ Joint Venture
☐ Subsidiaries of Multi-national

3) What Part of the Country do you cover?

☐ England ☐ Wales ☐ Scotland
☐ Northern Ireland ☐ UK wide

4) What is your industry area?

☐ Aerospace ☐ Automotive
☐ Food ☐ Textiles
☐ Chemical ☐ Utilities
☐ Telecommunications ☐ Mechanical
☐ Pharmaceuticals ☐ Plastics
☐ Electronics & discrete semiconductors
☐ Other (please specify):

____

5) How many employees does your organisation have?

☐ Less than 10 ☐ 10-49
☐ 50-250 ☐ over-250

6) What is your company's turnover (£)?

☐ Less than 1m ☐ 1m- 10m
☐ 10m- 20m ☐ 20m- 30m
☐ 30m- 50m ☐ over 50m

7) What is your current position within the company?

☐ CEO/ Director/ General Manager
☐ Departmental Head
☐ Quality manager
☐ Other (please specify): ________________

8) Do you have a quality department?

☐ Yes ☐ No

9) How do your company measure Customer Satisfaction?

☐ Surveys ☐ Delivery times
☐ Customer Complaints ☐ Sales Data
☐ Repeat Business ☐ Others

10) Which quality initiatives have been implemented in your Organisation?

Initiative	Current		Duration
Six Sigma	☐Yes	☐No	_______
TQM	☐Yes	☐No	_______
Lean	☐Yes	☐No	_______
Kaizen	☐Yes	☐No	_______
BPR*	☐Yes	☐No	_______
TOC*	☐Yes	☐No	_______
ISO 9000	☐Yes	☐No	_______
IIP*	☐Yes	☐No	_______
EFQM*	☐Yes	☐No	_______
Other (Please specify):__________________			
None	☐		

11) Are there teams in your company for problem solving?

☐ Yes ☐ No

12) If Yes, how often they meet?

☐ Few times/ week ☐ Once a week
☐ Once / 2 weeks ☐ Only when problem occurs
☐ Others (specify)________________________

13) How the employees imparted knowledge on quality improvements methods, tools and techniques?

☐ Training in company ☐ Conferences
☐ Consultants ☐ Internet
☐ Self-education ☐ Book / research articles
☐ Others (specify)________________________

14) Select the top three critical factors that define the company's strategic objective (s) (Tick up to 3 boxes that you consider are largest issues)

☐ Profitability ☐ Flexibility ☐ Quality
☐ Market Share ☐ Innovation ☐ Cost
☐ Others (specify)________________________

15) Select top three important criteria that helped your company to win customer loyalty (Tick up to 3 boxes that you consider are important)

☐Manufacturing Quality ☐ Product Reliability
☐ Delivery lead-time ☐ On-time delivery
☐ Wide Product range ☐ Price
☐ Others (specify)________________________

16)If your organisation is not implementing **Six Sigma**, please state the reasons for the same:

1 ______________________
2 ______________________
3 ______________________

* *BPR- Business Process Reengineering; TOC- Theory of Constraints; IiP- Investors in People; EFQM- European Foundation for Quality Management*

Part 2 Critical Success Factors

This section determines the degree of importance and implementation level for the factors that you consider to be crucial whilst implementing quality initiatives (QI) in your organisation. Please tick the appropriate box according to the following code:
(Use a five-point Likert scale from 1(not important) to 5 (very important) for importance and also use the same for the implementation level, from 1 (not implemented) to 5 (fully implemented).

	Importance (1 – 5)	Implementation Level (1 – 5)
Management Involvement and Commitment	□ □ □ □ □	□ □ □ □ □
Organisational Infrastructure	□ □ □ □ □	□ □ □ □ □
Cultural Change	□ □ □ □ □	□ □ □ □ □
Education and Training	□ □ □ □ □	□ □ □ □ □
Vision and Plan Statement	□ □ □ □ □	□ □ □ □ □
Linking Quality Improvement (QI) Initiative to Customers	□ □ □ □ □	□ □ □ □ □
Linking QI Initiative to Business Strategy	□ □ □ □ □	□ □ □ □ □
Linking QI Initiative to Employees	□ □ □ □ □	□ □ □ □ □
Linking QI Initiative to Suppliers	□ □ □ □ □	□ □ □ □ □
Communication	□ □ □ □ □	□ □ □ □ □
Project Management Skills	□ □ □ □ □	□ □ □ □ □
Project Prioritisation and Selection	□ □ □ □ □	□ □ □ □ □
Usage of Innovative techniques and IT systems	□ □ □ □ □	□ □ □ □ □

Others (Please Specify): ________________________
____

Part 3 Results of Implementation of Quality Improvement Program

This section asks about the benefits that your organisation has experienced following the implementation of Quality Improvement program in your business process(es). Please tick the appropriate box according to the following code:

1 Negative benefit / improvement
2 No benefit / improvement
3 Some benefit / improvement
4 Significant benefit / improvement
5 Crucial

1.	**1**	**2**	**3**	**4**	**5**	**Measure Not used in the company**
Reduction of scrap rate	☐	☐	☐	☐	☐	☐
Reduction of cycle time	☐	☐	☐	☐	☐	☐
Reduction of delivery time	☐	☐	☐	☐	☐	☐
Increase in productivity	☐	☐	☐	☐	☐	☐
Reduction of costs	☐	☐	☐	☐	☐	☐
Increase in profitability	☐	☐	☐	☐	☐	☐
Improved sales	☐	☐	☐	☐	☐	☐
Reduction of customer complaints	☐	☐	☐	☐	☐	☐
Reduction of Employee Complaints/Grievances	☐	☐	☐	☐	☐	☐

2. Do you understand the term Cost of Quality? ☐ Yes ☐ No

If you have answered Yes to question 2, please mention the factors that constitute cost of quality in your company.

____
____
____
____

3. What have been the **<u>Five</u>** largest issues you have faced during implementation of quality improvement initiatives?
(**Please select Five from the list**)

☐ Lack of top management commitment
☐ Lack of Knowledge
☐ Poor Supplier involvement
☐ Poor Employee Participation
☐ Poor Delegation of authority
☐ Lack of Training
☐ Inadequate process control techniques
☐ Availability of resources
☐ Changing business focus
☐ Internal resistance
☐ Poor project selection

4. Please use this space to tell us more about the successful (and unsuccessful) quality initiatives within your organization

Part 4 Contact Details

If you would like a copy of the results of this survey, please tick this box ☐
If you would like to participate in future study, please tick this box ☐

Please provide your contact details
Name…………………………………………………………………………………………
Organization ……………………………………………………………………………..
Address ……………………………………………………………………………………
Email ………………………………………………………………………………………
Fax Number ………………………………………………………………………………
Tel Number ………………………………………………………………………………

Thanks a lot for taking the time to complete this questionnaire. Please return it either by fax to 0141-552-0557 or post them to me,

Maneesh Kumar, M103, James Weir Building, 75 Montrose Street, University of Strathclyde Glasgow- G1 1XJ

APPENDIX III

Strathclyde Institute of Operations Management
Design Manufacturing and Engineering Management
University of Strathclyde
DOCTORAL RESEARCH INTERVIEW INVITE

SMEs AND SIX SIGMA – DOCTORAL RESEARCH INTERVIEW INVITE

Dear ____________________

I'd like to take this opportunity to thank you for participating in the first phase of research conducted by CRISSPI on assessing the status of UK manufacturing SMEs to implement Six Sigma. Based on the questionnaire that you completed a report will be prepared utilising the findings from the survey and will be sent to you for your perusal. The findings from this study have helped us to identify a number of SMEs existing quality practices including, performance metrics used in the company, critical success factors and barriers to implementation of quality initiatives.

The aim of this Doctoral research is to develop a **'Readiness Index'** that can identify the areas where the company is excelling in or underperforming. We will also be developing and proposing a **Six Sigma practical framework for SMEs** that would provide a guideline as how to get started with Six Sigma followed by sustaining the results achieved by implementing Six Sigma. This framework will be of practical utility to industry helping companies like yourselves evaluate your readiness for Six Sigma implementation.

In order to develop this framework, it is essential that I gain a more detailed picture of the quality practices in SMEs. This aim can be fulfilled through interviewing yourself and some of your colleagues including the Managing Director/ Operations Director and Quality Manager of your company. I am interested in hearing your experiences and challenges you have faced in deploying Quality Initiatives in your company. The interview process would not last for more than 90 minutes and will form, not only an integral part of my research but will also make a valuable contribution to the field of quality management. All responses will be treated with the utmost confidence and no single set of responses will be readily identifiable.

Please let me know your two or three available dates in next two months to schedule the meeting.

Thanks a lot in anticipation of your continued support

Kind Regards

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Six Sigma SMEs Interview Questionnaire

Brief Outline of the company background (start year, size, turnover, independent or part of big firm, key product, key process, key customer)

Quality Management Practices in SMEs

1. What specific quality improvement initiatives have been implemented till date?
2. How was the experience of the company with previous quality improvement initiatives?
3. If the initiative failed, what were the possible reasons for its failure?
4. Why Six Sigma for the company?
5. When the company was first introduced to Six Sigma?
6. How did the top management communicate the need for Six Sigma strategy?
7. What communication methods are in place to communicate the need for Six Sigma across the employees at all level and progress of the initiative?
8. Is there any specific roadmap you used in implementing Six Sigma? Is so, please go through it
9. Do you measure the commitment of the top management for the Six Sigma program? Is so, how committed the top management people are with regard to Six Sigma?
10. Who is responsible for quality improvement in the firm? Explain the existing organizational infrastructure in the firm, e.g. number of Yellow Belt, Green Belt, Black Belts in the firm
11. How effective ISO 9000 or any other certification has been in improving the business functioning and performance?
12. What are advantages & limitations of ISO 9000 in your viewpoints?
13. What tools and techniques of continuous improvement are used for process improvement? *(Please mark it on a table provide in a separate sheet)*

CSF's and Barriers to Implementation

1. What were the problem and obstacles experienced during Six Sigma implementation?
2. What factors were identified as critical to the success of Six Sigma in the firm?

Six Sigma and Performance Management

1. What are the established performance metrics in the firm?
2. Has Six Sigma facilitated any organizational change? If yes, in what way?
3. What was the impact of Six Sigma on organizational performance? Discuss the hard and soft benefits realised from implementation? Also mark the changes observed in the performance metrics after Six Sigma implementation *on a table provide in a separate sheet*

Readiness for Six Sigma

1. What do you think from your experience a company should have before embarking on Six Sigma or when can you say that company is ready for Six Sigma?
2. How the company realised that they are ready for Six Sigma?
3. Do you think that size of the organization affects the implementation of Six Sigma? If yes in what way? Is there any link between growth models of SMEs and implementing Quality program in your firm?

Non- Six Sigma SMEs Interview Questionnaire

Brief Outline of the company background (start year, size, turnover, independent or part of big firm, key product, key process, key customer)

Quality Management Practices in SMEs

1. What specific quality improvement initiatives have been implemented till date?
2. How was the experience of the company with previous quality improvement initiatives?
3. If the initiative failed, what were the possible reasons for its failure?
4. What is your understanding of Quality Management System/ ISO 9000?
5. When and how was ISO 9000 implemented in the company (framework, implementation plan, external consultant, level of employee involvement)?
6. Did the top management communicate the need for ISO certification to employees?
7. What was the company motive for implementing ISO 9000 (improve quality; satisfy major client; hold on to clients; win new customers; increase profit; preferred supplier status; global competitiveness, Government regulations; Corporate Mandate)
8. What communication methods are in place to share the benefits or impact of ISO on company performance across the employees at all level?
9. How ISO works in the company? Does ISO improve product quality?
10. What are advantages & limitations of ISO 9000 in your viewpoints?
11. Is ISO 9000 a good foundation/springboard for pursuing Six Sigma? If yes, what aspect of ISO can facilitate the implementation?
12. Who is responsible for quality improvement in the firm? Explain the existing organizational infrastructure in the firm, e.g. number of Yellow Belt, Green Belt, Black Belts in the firm
13. What tools and techniques of continuous improvement are used for process improvement? *(Please mark it on a table provide in a separate sheet)*

CSF's and Barriers to Implementation

1. What were the problem and obstacles experienced during ISO/Lean implementation?
2. What factors were identified as critical to the success of certification system or Lean in the firm?

Six Sigma and Performance Management

1. What are the established performance metrics in the firm?
2. Has ISO/Lean facilitated any organizational change? If yes, in what way?
3. How effective ISO 9000 / Lean or any other QP has been in improving the business functioning and performance? Also mark the changes observed in the performance metrics after ISO/Lean implementation *on a table provide in a separate sheet*

SMEs vs. Large Organizations

1. What are the critical differences between SMEs and large organizations in respect to quality management practices? Is there any link between growth models of SMEs and implementing Quality program in your firm?

Practitioner's Interview Questionnaire

Brief Outline of your background (Position, how long you have been working, etc.……)

1. Involvement with SMAS/MAS/MI for how many years?
2. What are your key responsibilities?
3. How many SMEs you have helped till date?
4. Understanding of QMS (ISO)- Its advantages and disadvantages for SMEs
5. Most commonly used quality initiatives in SMEs and reason for the same
6. Possible reasons for failure of QI in SMEs
7. How do SMEs interact with customers and suppliers?
8. How do SMEs measure the satisfaction of customers?
9. What are the most common tools and techniques (Top 5) used for improving process performance? (refer to table)
10. From your perspective, how do you measure the success of CI programs that you have implemented in SMEs?

Six Sigma Implementation Plan

1. How do you carry out review of existing processes in companies? Do you follow a series of steps or a roadmap to carry out the assessment
2. How commonly the initiatives like Lean and Six Sigma are implemented in all business functions of SMEs?
3. Do you think a company should have ISO as a foundation before they embark on Six Sigma? What is your experience on that?
4. Why Six Sigma is imperative for SMEs?
5. Is there any specific roadmap you used in implementing Six Sigma? Is so, please go through it
6. What should be the infrastructure (No., of BB, GB, YB, etc) in SMEs? Should it be similar to large org.? Do SMEs need lot of BB??

Six Sigma and Performance Management

4. What are common performance measures in SMEs?
5. How does the Six Sigma program impact the organizational performance at its strategic level, operational level and tactical level?

CSF's and Barriers to Implementation

14. What is the key to successful change programme, e.g. trust b/w employee and management, communication, training, etc?
15. What were the problem and obstacles experienced during Six Sigma implementation?

Readiness for Six Sigma

4. Do you think that size of the organization affects the implementation of Six Sigma? Is there any link between growth models of SMEs and implementing Quality program in your firm?
5. What do you think from your experience a company should have before embarking on Six Sigma or when can you say that company is ready for Six Sigma?

1.Tools & Techniques used in the firm

Tools & Techniques	Tick the one known & used in firm
Basic Tools	
Cause & Effect	
Check Sheet / Tally Sheet	
Control Charts	
Histogram	
Pareto Charts	
Scatter Diagram	
Process Map	
Brainstorming	
Management tools	
Affinity Diagrams	
Relations Diagram	
Tree Diagram	
Matrix data analysis	
Matrix diagrams	
Arrow diagram	
Process decision program chart	
Other tools & techniques	
5S	
Kanban	
Benchmarking	
Balance Scorecard	
Statistical Process Control (SPC)	
Failure Mode and Effect Analysis (FMEA)	
Value Stream Mapping (VSM)	
Measurement System Analysis (MSA)	
Design of Experiments (DoE)	
Quality Function Deployment (QFD)	
Hypothesis Testing	
Regression Analysis	
Force Field Analysis	
Quality Costing	
Total Productive Maintenance	
Mistake Proofing	

2. Impact of QP/Certification on Performance Metrics

	Performance Evaluation of Firm on the 1-5 Likert scale questions
Performance Indicators	
Reduction in scrap rate Reduction in cycle time Reduction in delivery time Increase in productivity Reduction of costs Increase in profitability Improved sales Reduction of customer complaints Reduction of Employee Complaints/Grievances	

1 = negative benefit / improvement; 2 = no benefit / improvement; 3= some benefit / improvement; 4=significant benefit / improvement; 5 =Crucial; *6 = measure not-used*

APPENDIX IV

Six Sigma Readiness Index Questionnaire

Six Sigma readiness index for SMEs is defined as '*the extent of SMEs preparedness to the introduction of Six Sigma*'. *It is also a way of assessing the degree to which the organization's present values are congruent with the values needed in a Six Sigma organization*. Established criteria for readiness index aim to measure the organizational practices in the past to ascertain their status on the CI journey and understand the role played by leadership team in driving the CI activities.

Participating firms are requested to rate the Readiness variables on a Likert scale of 0-4 (*0= percept not implemented; 1= percept slightly implemented; 2= percept moderately implemented; 3= Good implementation of percept; 4 = percept fully implemented and practised).*

Please answer following question before filling in the readiness index questionnaire

1. Is your firm going through major organizational restructuring? **YES / NO**
2. Is your firm going through merger & acquisition? **YES / NO**
3. Is your firm going through change in leadership or management? **YES / NO**

If you have answered **YES** to any of the questions, it is not the right time for the firm to implement Six Sigma. You are not required to answer the readiness questionnaire.

Thanks for your response

Criteria/ Precepts to measure Readiness Index	Measurement Scale				
	0	1	2	3	4
Leadership					
L1- Visible involvement and continued commitment in leading companywide quality initiatives in the past (e.g. being available to speak to staff, operating an 'open door' policy, walk the floor, holding briefing and feedback meetings)					
L2- Understands and supported continuous improvement (CI) in the past by provision of appropriate resources, assistance, and breaking down stumbling blocks					
L3- Effectively communicated vision and mission, long-term quality goals and objectives vertically down the organization to achieve quality excellence					
L4- CI within the top business priority and strategically linked to business goals					
L5- Recognised and appreciated the efforts and success of individuals and teams					
Measurement and Processes					
M1- All major business processes identified and documented (using flowcharts or process mapping techniques)					
M2- Key internal and external performance measures identified, defined, and developed					
M3- Basic tools of CI understood and used by employees for problem solving					
M4- Operations and decisions based on fact and data					
M5- Performance indicators monitored, displayed and communicated through debriefing sessions, intranet, and bulletin boards on a continuous basis					
People Management					
P1- Employee's knowledge and competencies linked to training & development strategies, and career progression identified, developed, and sustained					
P2- Employees respected accountability and discouraged blame culture					
P3- Employees feel free to report information on errors and defect					
P4- Organization promoted the involvement of all its employees in quality and CI					
Systems & Control					
S1- A policy deployment and problem-solving infrastructure in place together with robust and proactive quality system					
S2- A high degree of closed loop error prevention through the control of basic production/ operation and/or service					

processes					
S3- Effective communication system and timely information flow vertically and horizontally at all levels					
S4- Standardised procedures in a documented quality management system (religiously follow the principles of ISO 9000; certification not required until asked by customer; or identified value added activities through lean implementation)					
S5- Cross-functional team established as a way of working and to take decisions on system-wide problems					
Customer Focus					
C1- Organization regularly seeks customer feedback to understand the key causes of concern, main complaints, and expected performance from customers					
C2- Customer focus and satisfaction given priority over internal policies					
C3- Understanding of value-added and non-value added activities from customer perspective					

APPENDIX V

List of Publications during the tenure of Doctoral Research

Journal Papers

- **Kumar, M.,** and Antony, J., Tiwari, M.K., Six Sigma Implementation Framework for SMEs – A roadmap to manage and sustain the change, *International Journal of Production Research* (Accepted for publication in 2010)
- **Kumar, M.,** and Antony, J., The Impact of Six Sigma Implementation in UK Manufacturing SME: Findings from a Pilot Case Study, *International Journal of Quality and Reliability Management* (Accepted for publication in 2010)
- **Kumar, M**., and Antony, J., (2009), Investigating the quality management practices in Six Sigma against Non-Six Sigma UK Manufacturing SMEs: Key findings from multiple case studies, *Journal of Engineering Manufacture, IMECH E Part B* , Vol.223, No.7, pp. 925-934.
- **Kumar, M.**, Antony, J., Douglas, A., (2009), Does Size matter for Six Sigma implementation?-Findings from the survey in UK SMEs, *The TQM Journal,* Vol.21, No.6, pp.623-635
- **Kumar, M.**, Antony, J., (2008), Comparing the Quality Management Practices in UK SMEs, *Industrial Management and Data System,* Vol. 108, No.9, pp.1153-1166
- **Kumar, M.**, Antony, J., Madu, C., Montgomery, D.C., Park, S.H., (2008), Common myths of Six Sigma demystified, *International Journal of Quality and Reliability Management*. Vol.25, No.8, pp.878-895.
- Antony, J., **Kumar, M.,** Labib, A., (2008), Gearing Six Sigma into UK Manufacturing SMEs: An Empirical assessment of Critical Success factors, Impediments, and viewpoints of Six Sigma implementation in SMEs, *Journal of Operations Research Society*. Vol.59, No.4, pp.482-493
- **Kumar, M**., (2007), Success Factors and Hurdles to Six Sigma Implementation: the case of a UK manufacturing SME, *International Journal of Six Sigma and Competitive Advantage* , Vol.3, No.4, pp. 333-351
- Antony, J., **Kumar, M.** and Madu, C.N., (2005), Six Sigma in Small and Medium Sized UK Manufacturing Enterprises: Some Empirical Observations, *International Journal of Quality and Reliability Management*, Vol.22, No.8, pp.860-874.

Conference Papers

- **Kumar, M.,** Antony, J., (2010), Six Sigma Readiness Index for SMEs, 7th-10th May 2010, *21st Annual Production and Operations Management Conference*, Vancouver, Canada
- **Kumar, M.,** Antony, J., (2010), Feasibility study of Six Sigma in UK SMEs: Multiple-Case Study Analysis, *17th International Annual EurOMA Conference*, 6th-9th June, Porto, Portugal
- **Kumar, M.,** Antony, J., (2009), Longitudinal study on Six Sigma status in UK SMEs, 18th -20th May 2009, *World Conference on Quality* Improvement, Minneapolis, USA [2nd Best Student paper Award]
- **Kumar, M.,** Antony, J., (2008), Comparing the quality management practices between Six Sigma and ISO certified SMEs- a survey based approach, 25th -27th June 2008,

13th International Conference on Productivity and Quality Research, Oulu, Finland [Best Student paper Award]

- **Kumar, M.,** Antony, J., (2008), Six Sigma myth demystified - Multiple case study analysis of Six Sigma application in UK SMEs, 9-11 September 2008, *British Academy of Management Conference*, Harrogate, United Kingdom.
- Antony, J., **Kumar, M.,** (2008), Six Sigma implementation in UK manufacturing SMEs: A multiple case- study analysis and key findings, 4th- 6th June 2008, *Quality and Productivity Research Conference,* Madison, Wisconsin, USA.
- **Kumar, M.**, Upadhyay, S., Ogbu, C., Antony, J., (2008), An investigation of Six Sigma implementation within UK manufacturing SMEs: Findings from the survey, 10th March, 2008, *First European Research Conference on Continuous Improvement and Lean Six Sigma*, University of Strathclyde, Glasgow.
- **Kumar, M.,** (2008), Assessing the readiness of Six Sigma implementation in UK Small and Medium-Sized Enterprises (SMEs), 15th January 2008, *Research Presentation day, Faculty of Engineering, University of Strathclyde*.
- **Kumar, M.**, Antony, J., Hari, S., Wang, C., (2006), Evaluating the relationship between Six Sigma and Organizational Performance: A case study from a UK SME, *British Academy of Management Conference*, 12th- 15th September, Belfast, UK.
- Antony, J., and **Kumar, M.**, (2006), Six Sigma in UK Manufacturing SME-A Case Study, *ENBIS 6,*18th – 20th September 2006, Wroclaw, Poland.
- Antony, J., **Kumar, M.**, and Deas, A., (2005), Assessing the Status of Six Sigma Implementation in UK Manufacturing SMEs, *3rd European Conference on Intelligent Management Systems in Operations*, 28-29th June 2005, Salford, United Kingdom.
- **Kumar, M.,** Antony, J., Hari, S., Perry, D., (2005), The Relationship between Critical Success Factors of Six Sigma and Organisational Performance, *International Conference on Quality and Productivity Research*, 12th-15th December 2005, IIT Delhi, India.

Workshop/ Seminar delivered

- Workshop on “Six Sigma for the Little Guy”*, Third International Conference on Six Sigma,* 15th- 16th December 2008, Edinburgh (3hours)
- Introductory Workshop on “The Status of Six Sigma within UK manufacturing SMEs”, *Second International Conference on Six Sigma*, 6th – 8th June 2006, Glasgow (3 hours)
- One Day Workshop on “Six Sigma for the Little Guy”, Partick Burgh Hall, Glasgow, 1st November 2006
- Invited as the panel member on a research seminar organized by University of Strathclyde on ‘Six Sigma for the Little Guy’ on 25th November, 2009