



University of Technology, Sydney

**Development of a Lean Six Sigma Implementation
Framework for Small and Medium Sized Indonesian
Manufacturing Enterprises**

By

Kifayah Amar

A thesis submitted to fulfillment of the requirements
for the degree of Doctor of Philosophy

**Faculty of Engineering and Information Technology
University of Technology, Sydney
Australia**

2010

Certificate of Authorship/Originality

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated and referenced in the thesis.

Signature of Candidate

Production Note:
Signature removed prior to publication.



I dedicate this thesis to my beloved parents:

Fatmah Ashiblie and Khalid Amar

Acknowledgments

Alhamdulillah, finally I can finish my thesis because of Allah SWT's blessings, He is the merciful who always answered my prayers.

I would like to extend my sincere thanks and appreciation to my principal supervisor, Dr Douglas Davis for his supervision. In particular, I am grateful for his advice and ideas in order to improve my thesis.

I also want to acknowledge the support of my co-supervisors, Dr Bruce Moulton and Dr Udisubakti Ciptomulyono, for their feedback on my research instrument and comments on the final draft of my thesis.

A special thanks to people in the Faculty of Engineering, particularly for the support provided by Professor Hung Nguyen and Dr Scott Smith during my candidature. Also, to Ms. Phyllis Agius, Ms. Gunasmin Lye and Ms. Anya Van Euwen for their administration help during my study at UTS.

I would also address my thanks to people in my institution for their support during my study in Australia. In particular, my thanks to Professor Amin Abdullah, Mr. Jarot Wahyudi and staff in PMU of UIN Sunan Kalijaga Yogyakarta, Indonesia. I also extend my thanks to my colleagues, Mr. Agung Fatwanto, Mr. Muhammad Anshari and Ms. Siswati Lestari, for their warm friendship during my study life here.

Thanks to all the respondents of this research survey for sharing their time and information, and also to Indonesian Government and non-Government representatives for their time and information provided during interviews.

I would like to address my thanks to people who gave their advice and help during my research and writing of this thesis, in particular, Dr John Chelliah and Dr John Crawford for their valuable comments on this thesis. I would like to address my thanks to my best friend Ms. Himiwati Purnamasari who supported me emotionally and materially during

the hard times of data collection. Valuable support also came from Mr. Syahmi and Miss Filzah during administration of the questionnaire. Thanks also to Ms. Zuhra Mahyuddin, Ms. Pedy Artsanti who supported me in spirit and with prayers. I would also like to acknowledge the support of my colleagues in the lovely CB02/303 UTS City Campus in particular Ms. Khorshed Jahan Chinu, Mr. Javeed Muhammad Abdul, Mr. Nassif , Mr. Thanh Nguyen, Ms. Layegha Hasemi and Ms. Mahira Atham Lebbe from CB01/2210. I also extend my thanks to my editor and proofreaders, Ms. Emily Hunter, Ms. Lyndal Parker and Ms. Sue Felix, for their excellent works.

My thanks also go to Mr. Osgar Ravasia and Ms. Rahimah Banu for their support during my life in Sydney. Sincere appreciation is also due to Mr. Shabir Ahmed, Ms. Alom Shair and their family, especially Noor Azizah, Yasmeen Fatimah and Tasneem Fatimah.

I wish to express my sincere thanks to my family for their huge support during my study. In particular, I thank my father, Khalid Amar and my mother, Fatmah Ashiblie for their love and prayers. I also deeply thank my beloved sister, Dr Ferial Khalid Amar, and my beloved brothers, Ady Khalid Amar and Rifqy Khalid Amar for their love, care and especially their time in looking after our parents.

Finally, my thanks go to my beloved husband, Yusri Syam Akil, for his love, care and (always) encourage me particularly during the hard times of finishing this thesis.

Table of Contents

Certificate of Authorship/Originality	ii
Acknowledgements	iv
Table of Contents	vi
List of Tables	xii
List of Figures	xiv
List of Publications Resulting from this Research	xv
List of Appendices	xvi
Glossary	xvii
Abstract	xix

Chapter 1 Introduction

1.1 Background to the Research	1
1.2 Research Objectives	5
1.3 Scope of Research	5
1.4 Justification of Research	5
1.5 Research Resources	7
1.6 Structure of Thesis	8

Chapter 2 Literature Review

2.1 Introduction	11
2.2 Small and Medium Enterprises (SMEs)	12
2.2.1 Definition of SMEs	12
2.2.2 Differences between SMEs and Large Organisations	14
2.2.3 Current Condition of SMEs in Indonesia	17
2.2.4 Government and Non-Government Support for SME in Indonesia	18
2.2.5 Other Countries' Experience in Innovation Support for SMEs	22

2.3	Quality Concepts	26
2.3.1	Quality Concept Evolution	27
2.4	Six Sigma	35
2.4.1	History of Six Sigma	38
2.4.2	Similarities between Six Sigma and Other Improvement Approaches	40
2.5	Lean Six Sigma	42
2.5.1	Explanation of Lean Six Sigma	42
2.5.2	Tools and Techniques of Lean Six Sigma	45
2.5.3	Organisation of Lean Six Sigma	47
2.6	Research on Six Sigma and Lean Six Sigma	49
2.6.1	Critical Success Factors of Six Sigma and Lean Six Sigma	49
2.6.2	Six Sigma and Lean Six Sigma Frameworks/Models	52
2.7	Quality Improvement in Indonesia	55
2.8	Diffusion of Innovations Theory	58
2.8.1	Elements in the Diffusion of Innovations Theory	58
2.8.2	Examples of Research on Diffusion of Innovations	63
2.9	Evaluation of Six Sigma and Lean Six Sigma Frameworks	65
2.9.1	Analysis Based on Diffusion of Innovations Theory	65
2.9.2	Analysis Based on Critical Success Factors (CSFs)	67
2.10	Summary	68

Chapter 3 Theoretical Framework

3.1	Introduction	70
3.2	Identification of Subjects for Research	70

3.3	Link to the Methodology	71
3.3.1	Issues Related to Compatibility	71
3.3.2	Issues Related to Communication Channels	71
3.3.3	Issues Related to the Leader Characteristics	72
3.3.4	Issues Related to the Organisational Slack	72
3.3.5	Issued Related to Change Agents	73

Chapter 4 Methodology

4.1	Introduction	74
4.2	Data Collection from SMEs	75
4.2.1	Sample Plan for the Questionnaire Survey	75
4.2.2	Questionnaire Design	77
4.2.3	Questionnaire Translation Pre-testing	81
4.2.4	Questionnaire Administration	82
4.2.4.1	Initial Plan for Questionnaire Distribution	83
4.2.4.2	Revision to Questionnaire Distribution	83
4.2.5	Questionnaire Response Rate	84
4.2.6	Data Coding	85
4.2.7	Missing Data	85
4.2.8	Design and Conduct of Interviews with SME Owners/Managers	86
4.3	Data Collection from Other Relevant Subjects	87
4.3.1	Sample Plan of Interviews	87
4.3.2	Interview Design	87
4.4	Analysis of Data	88
4.4.1	Analysis of Questionnaire Responses	88
4.4.2	Analysis of Qualitative Data	90
4.5	Ethics Approval	90
4.6	Summary	91

Chapter 5 Results

5.1	Introduction	92
5.2	Quantitative Results	93
5.2.1	Demographics and General Information	93
5.2.1.1	Position of Respondent in the Organisation (QA1)	93
5.2.1.2	Location of Responding SMEs (QA6)	93
5.2.1.3	Company Size (QA2)	94
5.2.1.4	Length of Time in Business (QA3)	95
5.2.1.5	Company Ownership (QA4)	95
5.2.1.6	Main Products Produced (QA5)	96
5.2.1.7	Market Orientation (QA8)	96
5.2.1.8	Quality Certification (QA7)	97
5.2.1.9	Use of IT (QA9)	97
5.2.2	Understanding and Usage of Improvement Programs (Part B1 of Questionnaire)	98
5.2.3	Understanding and Usage of Improvement Tools and Techniques (Part C of Questionnaire)	99
5.2.4	Strength and Importance of Support for SMEs (Part B2 of Questionnaire)	102
5.2.5	Readiness to Adopt Innovation (Part D of Questionnaire)	104
5.2.5.1	Company Practices (Section D1)	104
5.2.5.2	Resource Availability (Section D2)	106
5.2.5.3	Management Support (Section D3)	106
5.2.5.4	Employee Commitment and Ability (Section D4)	107
5.2.5.5	Provision of Training (Section D5)	108
5.2.6	Influences and Expectations (Part E)	109
5.2.7	Belief that Program Will Succeed (Part E2 of Questionnaire)	110

5.3	Further Analysis of Quantitative Data	111
5.3.1	Data Reduction	112
5.3.2	Descriptive Statistics of Readiness Variables	113
5.3.3	Correlation Analysis	114
5.3.4	Regression Analysis	115
5.4	Identifying Leading SMEs	117
5.5	Qualitative Result	118
5.5.1	Views of SME Owners/Managers	119
5.5.2	Views of Government Representatives	121
5.5.3	Views of Non-Government Representatives	122
5.6	Summary	123

Chapter 6 Discussion of Results and Development of a Lean Six Sigma Implementation Framework

6.1	Introduction	125
6.2	Key Findings	125
6.2.1	General Aspects of Respondents	126
6.2.2	ISO 9001 Certification	127
6.2.3	IT Usage	127
6.2.4	Understanding and Implementation of the Improvement Programs, Tools and Techniques	128
6.2.5	Strength and Importance of Support for SMEs	129
6.2.6	Decision to Adopt Innovation in SMEs	132
6.2.7	Other Important Issues Related to the Readiness to Adopt Innovation	132
6.3	Key Points of the Research for Framework Development	135

6.4	Development of a Lean Six Sigma Implementation Framework for Indonesian SMEs	136
6.4.1	Key Elements of the Framework	136
6.4.1.1	Owner/manager Commitment and Involvement	137
6.4.1.2	Training	139
6.4.1.3	Employee Involvement	141
6.4.1.4	Culture Change	142
6.4.1.5	External Support	143
6.4.2	Implementation Framework of Lean Six Sigma	144
6.5	Reflection on Research Questions	147
Chapter 7 Conclusions and Recommendations		
7.1	Conclusions	149
7.2	Contribution to the Research	150
7.3	Policy Implications	151
7.4	Limitation and Recommendation of Further Research	152
7.4.1	Limitations	152
7.4.2	Recommendations for Further Research	153
	Reference List	154

List of Tables

Table 2.1	Definitions of SMEs in Indonesia	13
Table 2.2	Comparison between large organisations and SMEs	14
Table 2.3	Total number of enterprises in the manufacturing sector in Indonesia	17
Table 2.4	Comparison of export share of ASEAN SMEs	18
Table 2.5	Summary of policies and programs for the development of SMEs in Indonesia	19
Table 2.6	Some differences between TQM and Six Sigma based on the literature	41
Table 2.7	Waste type in Lean concept	42
Table 2.8	Lean and Six Sigma tools	45
Table 2.9	The common use of Lean Six Sigma tools based on DMAIC cycle	47
Table 2.10	Levels of Six Sigma training	48
Table 2.11	Examination of existing frameworks based on Rogers' diffusion of innovations	66
Table 2.12	Examination of existing frameworks based on CSFs	67
Table 4.1	Summary of questionnaire item sources for Part D	80
Table 4.2	Distribution of questionnaire	85
Table 5.1	Position of the respondent	93
Table 5.2	Location of responding SMEs	94
Table 5.3	Number of employees	95
Table 5.4	Length in business	95
Table 5.5	Company ownership	96
Table 5.6	Product type	96
Table 5.7	Market orientation	97
Table 5.8	Quality certification	97
Table 5.9	Understanding and usage of improvement programs	99
Table 5.10	Understanding and usage of improvement tools and techniques	101
Table 5.11	Company practices	105
Table 5.12	Resource availability	106

Table 5.13	Management support	107
Table 5.14	Employee commitment and ability	108
Table 5.15	Provision of training	109
Table 5.16	External influences on SMEs to adopt innovation	109
Table 5.17	Readiness variables (Part D of questionnaire)	113
Table 5.18	Mean of readiness variables	114
Table 5.19	Correlation of readiness variables	115
Table 5.20	Regression result	116
Table 5.21	Ranking of SME based on mean of readiness variables	118
Table 6.1	Current and ideal supports for SMEs	131
Table 6.2	Management commitment and involvement at pre-implementation and implementation stages of Lean Six Sigma	138
Table 6.3	Training design on Lean Six Sigma for SMEs	140
Table 6.4	Employee involvement activities	142
Table 6.5	Culture change in SMEs at the implementation stage of Lean Six Sigma	142
Table 6.6	External support to implement Lean Six Sigma	143

List of Figures

Figure 1.1	Structure of thesis	8
Figure 2.1	Small organisation assisted by large organisation in quality practice	21
Figure 2.2	Innovation support system in Korea	23
Figure 2.3	Deming's chain reaction	27
Figure 2.4	MBNQA framework	34
Figure 2.5	Theoretical basis of Six Sigma	37
Figure 2.6	DMAIC circle	37
Figure 2.7	Evolution of quality practices in General Electric	38
Figure 2.8	Movement from simple approach to Lean Six Sigma	40
Figure 2.9	Integration of Lean and Six Sigma to improve overall organisational performance	44
Figure 2.10	Chang's Six Sigma framework for SMEs	53
Figure 2.11	Park's Six Sigma framework	53
Figure 2.12	Six Sigma implementation framework for SMEs	54
Figure 2.13	Lean Six Sigma framework	55
Figure 2.14	Quality management journey in Asian countries	57
Figure 2.15	Variables that influence the rate of adoption of innovations	59
Figure 2.16	The relationship between independent variables and organisational innovativeness	62
Figure 5.1	Degree of IT usage	98
Figure 5.2	Mean values of understanding and usage of improvement tools/techniques	100
Figure 5.3	Mean values strength and importance of support for SMEs	103
Figure 5.4	External entities' influence on SMEs in adopting innovation	110
Figure 5.5	Belief that a new program will succeed	111
Figure 6.1	Framework for Lean Six Sigma Implementation in SMEs	137
Figure 6.2	Lean Six Sigma roadmap for Indonesian SMEs	145

List of Publications Resulting from this Research

Amar, K. & Davis, D. (2007), "Evaluating Six Sigma in the Indonesian SME Context", published in the Proceedings of the 5th ANZAM and 1st Asian Pacific Operations Management Symposium, 6-7 June, Melbourne.

Amar, K. & Davis, D. (2008), "A Review of Six Sigma Implementation Frameworks and Related Literature", published in the Proceedings of the IAENG: International Conference on Industrial Engineering, 19-21 March, Hong Kong.

Amar, K. & Davis, D. (2008), "Are Indonesian SMEs Prepared for Lean Six Sigma?", published in the Proceedings of the 13th International Conference on ISO 9000 and TQM, 24-26 March, Kuala Lumpur.

List of Appendices

Appendix A	Preliminary interview questions	161
Appendix B	English version of questionnaire	163
Appendix C	Indonesian version of questionnaire	172
Appendix D	Semi-structured interviews	183
Appendix E	Letter of approval from UTS research ethics committee	185
Appendix F	English version of follow-up letter	186
Appendix G	Indonesian version of follow-up letter	187
Appendix H	Questionnaire coding sheet	188
Appendix I	Questionnaires variables, summary statistics and missing data	196
Appendix J	Histograms of data responses of readiness variables	203
Appendix K	Paired T test result for means difference of influence from external entities	229
Appendix L	T test result for means difference of expectation between sample groups	244
Appendix M	T test result for means difference of readiness variables between sample groups	247
Appendix N	Factor analysis result	260
Appendix O	Multiple regression results	274

Glossary

ABS	Australian Bureau of Statistics
ASEAN	Association of South East Asian Nations
BDS	Business Development Services
BPR	Business Process Re-engineering
BPS	Central Bureau of Statistics
BSN	National Standardization Agency of Indonesia
CSF	Critical Success Factors
CTQ	Critical to Quality
DMAIC	Define-Measure-Analyse-Improve-Control
DOE	Design of Experiments
FAZAT	Research and Training Center for Labour and Technology Steyr
FFF	Austrian Industrial Research Promotion Fund
Five S (5S)	Seiri, Seiton, Seiso, Seiketsu, Shitsuke
FMEA	Failure Mode and Effect Analysis
GB	Green Belt
IDB	Islamic Development Bank
IFC	International Finance Corporation
IPO	Input-Process-Output
ISO 9000	International Standards Organisation
IT	Information Technology
JICA	Japan International Cooperation Agency
JIT	Just In Time
LIK-UPT	Centre for Small Industry
LSS	Lean Six Sigma
MBB	Master Black Belt
MBNQA	Malcolm Baldrige National Quality Award
MITI	Ministry of Industry and Trade of Japan
MSA	Measurement System Evaluation

NIES	National Industry Extension Service
P3ED	Regional Export Training and Promotion Center
PPM	Part per Million
PUPUK	Association for the Advancement of Small Business
QCC	Quality Control Circle
QM	Quality Management
ROA	Return on Assets
ROE	Return on Equity
SCM	Supply Chain Management
SIPOC	Supplier-Inputs-Process-Outputs-Customers
SME	Small and Medium Enterprise
SMED	Single Minute Exchange of Dies
SMIs	Small and Medium Industries
SENADA	Indonesia Competitiveness Program
SNI	Standard National of Indonesia
SPC	Statistical Process Control
SQC	Statistical Quality Control
STM	Vocational High School
STEP	Shell Technology Enterprise Programme
SWP	Software Park Hagenberg
TPM	Total Productive Maintenance
TQM	Total Quality Management
UIN	Universitas Islam Negeri
UTS	University of Technology, Sydney
VIF	Variance Inflation Factors

Abstract

The main objective of this research was to develop an implementation framework for the introduction of the Lean Six Sigma improvement approach into small and medium enterprises (SMEs) in Indonesia. It was expected that an appropriate diffusion of Lean Six Sigma would assist the SMEs to improve their competitiveness.

The research involved a close examination of Indonesian SMEs and their support networks in order to evaluate the suitability of the Lean Six Sigma approach and to inform the design of an effective implementation framework.

Six Sigma is a popular business improvement approach. In Lean Six Sigma ideas from Lean Production (Womack, Jones and Ross 1984) have been incorporated with Six Sigma. There is some evidence that Lean Six Sigma has advantages over Six Sigma and provides a strengthened business improvement approach.

Rogers' diffusion of innovations theory is used as the theoretical framework for the research (Rogers 2003). The theory is particularly useful in guiding the diffusion of an innovation developed in one cultural setting into a different cultural setting.

The literature review covers the history and development of Six Sigma and Lean Six Sigma. Also, related approaches such as TQM and ISO 9000 are reviewed. A number of existing Six Sigma implementation frameworks were found in the literature and reviewed.

A review of Rogers' diffusion of innovations theory was undertaken. Also research identifying critical success factors (CSFs) associated with the implementation of improvement approaches such as TQM was undertaken. Rogers' theory and the CSFs literature were important inputs in the research methodology.

Literature on SMEs in general and Indonesian SMEs in particular was reviewed. The contribution of SMEs to the Indonesian economy, the various forms of support available to them and the stage of development of improvement programs was reviewed.

The majority of data were collected through the development and administration of a questionnaire survey completed by SME owners/managers. A sample of 148 usable questionnaires was obtained. Interviews were also conducted with SME owners/managers and other stakeholders e.g., government, Business Development Services (BDS), universities, customers and suppliers.

The results showed that SMEs had a relatively low usage of improvement tools and Information Technology (IT). This low technical base presents a challenge to the successful implementation of Lean Six Sigma. However, owners/managers were relatively optimistic about the success of such an innovation and reported encouraging levels of commitment both by themselves and their employees for such change.

The results established that SME owners/managers were most influenced by their key customers and other SMEs when making decisions about adopting an innovation. The results indicated a preference for face-to-face rather than virtual (online) training. Areas for improvement in the support provided to SMEs from government were reported.

The main outcome of this research is an implementation framework of Lean Six Sigma for SMEs. The frameworks' elements are owner/manager commitment and involvement, training, employee involvement, culture change and external support. The framework is designed specifically for the Indonesian SMEs context and includes the element 'external support' which is not present in any of the existing frameworks that were reviewed.