MANUFACTURING PERFORMANCE MEASUREMENT TOOL FOR SMALL AND MEDIUM-SIZED ENTERPRISES

ELITA AMRINA

A thesis submitted in fulfillment of the
requirements for the award of the degree of
Master of Engineering (Mechanical)

Faculty of Mechanical Engineering
Universiti Teknologi Malaysia

SEPTEMBER 2009

Dedicated with love and gratitude to my beloved mother, late father,
brothers, sisters, husband, and son.

ACKNOWLEDGEMENTS

In the name of Allah, the Most Gracious, the Most Merciful. I am thankful to Allah, Lord of the universe for making me able to undertake this research.

The completion of this thesis has involved a lot of people to whom I would like to express my sincere thanks and gratitude for their help. First, I would like to express my sincere appreciation to my supervisor, Prof. Dr. Sha'ri Mohd Yusof, for his invaluable guidance, encouragement, suggestions, and motivation. He has spent a lot of time and effort to discuss, guide, and comment on every aspect of this thesis.

Secondly, I would like to express my sincere thanks and deep gratitude to my mother for her encouragement, her love and care, and her support always to achieve and succeed. I am also grateful to my brothers, sister, and other family members for their love, constant support, understanding, and caring for all these years. I also want to express profound thanks to my husband and son for their love, support, encouragement and understanding. They have lost a lot due to my study abroad.

Special thanks to all members of E04 postgraduate room, all of my sweet family in L12 Kolej Tun Hussein Onn UTM, and all PPI-UTM members for their encouragement, discussion, kindness, and friendship. Finally, I want to express grateful thanks to MOSTI for funding my study. This support is gratefully acknowledged.

ABSTRACT

Competitive pressures in global manufacturing are forcing manufacturing organizations to re-examine and modify their competitive strategies. Small and Medium-sized Enterprises (SMEs) are not exempted from these pressures. They have to pay more attention to the changes in manufacturing performance system including the measures. Although manufacturing performance measurement has been in existence for many years, it seems that there is no consensus on the collective set of measures used by companies. Most researchers and authors defined the manufacturing performance measures in terms of quality, cost, delivery and flexibility. There is also a bulk of researches that used other measures such as time, human resources, financial, customer satisfaction, innovation, and efficiency. Very few researches have developed the manufacturing performance measurement for SMEs. Based on the literature review of previous studies, this study has proposed a set of manufacturing performance measures for SMEs consisting of six factors i.e. quality, delivery, cost, flexibility, time, and labor, which are the most commonly used measures in previous studies. A total of 32 dimensions were then derived from relevant literature. A survey has been conducted in matching the measures with industry practices. It was found that most of the measures are being applied by Malaysian automotive SMEs. Quality and cost were found to be the most frequently used, followed by delivery and time which also have high usage level, but labor and flexibility were placed at a low usage level. Finally, a total of 25 measures have been proposed to assess manufacturing performance in SMEs. Analytic Hierarchy Process (AHP) methodology was applied in developing a tool of manufacturing performance measurement for SMEs. This tool enables and assists SMEs in their efforts to continually improve their manufacturing performances so as to become efficient and effective. While the tool provides a systematic approach for quantitative assessment of manufacturing performance, it is not entirely automated. Thus for that purpose, a software-based tool was subsequently developed by using PHP and MySQL. Two case studies have been conducted to validate the tool. Results from the case studies suggested that the tool is appropriate and suitable to assess manufacturing performance in SMEs. The tool identifies the strengths and weaknesses that indicate where and how improvements need to be made. It provides the direction to practice continuous improvement towards achieving excellence.

ABSTRAK

Tekanan persaingan dalam perkilangan global memaksa organisasi perkilangan untuk menyelidiki semula dan mengubah rancangan persaingan mereka. Industri kecil dan sederhana tidak terkecuali dari tekanan ini. Mereka harus memberikan lebih perhatian terhadap perubahan dalam sistem prestasi perkilangan termasuk ukurannya. Meskipun pengukuran prestasi perkilangan telah lama ada, ia kelihatannya tidak ada persetujuan atas susunan kumpulan ukuran yang digunakan oleh pihak syarikat. Kebanyakan penyelidik dan penulis menentukan ukuran prestasi perkilangan dalam istilah kualiti, kos, penghantaran, dan fleksibiliti. Ada juga sejumlah besar penyelidik yang memakai ukuran lain seperti masa, sumber daya manusia, kewangan, kepuasan pelanggan, pembaharuan, dan kecekapan. Sangat sedikit penyelidik yang membangunkan pengukuran prestasi perkilangan untuk industri kecil dan sederhana. Berdasarkan tinjauan literatur terhadap kajian terdahulu, kajian ini mencadangkan sekumpulan ukuran prestasi perkilangan untuk industri kecil dan sederhana, yang terdiri dari kualiti, penghantaran, kos, fleksibiliti, masa, dan buruh, yang mana merupakan ukuran umum yang dipakai dalam kajian-kajian yang dahulu. Sejumlah 32 elemen ukuran telah diperolehi dari literatur yang berkaitan. Satu kajian soal selidik telah dijalankan untuk membandingkan ukuran tersebut dengan amalan industri. Didapati sejumlah besar ukuran diaplikasikan oleh industri kecil dan sederhana automotif di Malaysia. Kualiti dan kos menunjukkan penggunaan yang paling kerap, diikuti dengan penghantaran dan masa juga pada tingkat penggunaan tinggi. Walau bagaimanapun, buruh dan fleksibiliti ditempatkan pada tingkat penggunaan rendah. Akhirnya, sejumlah 25 ukuran telah dicadangkan untuk menentukan prestasi perkilangan dalam industri kecil dan sederhana. Kaedah AHP telah diaplikasikan dalam membangunkan suatu alat bagi mengukur prestasi perkilangan untuk industri kecil dan sederhana. Alat ini membolehkan dan membantu industri kecil dan sederhana dalam usaha mereka untuk memperbaiki prestasi perkilangan secara berterusan supaya menjadi lebih efisien dan efektif. Walaupun alat ini menyediakan suatu pendekatan sistematik untuk penentuan kuantitatif prestasi perkilangan, namun ia tidak sepenuhnya automatik. Oleh itu, satu perisian berdasarkan alat ini telah dibangunkan dengan menggunakan PHP dan MySQL. Dua kajian kes telah diadakan untuk mengesahkan alat ini. Keputusan daripada kajian kes ini mencadangkan alat ini adalah tepat dan sesuai digunakan untuk menentukan prestasi perkilangan dalam industri kecil dan sederhana. Alat ini mengenal pasti kekuatan dan kelemahan yang menunjukkan di mana dan bagaimana pembaharuan perlu dilakukan. Alat ini menyediakan arah untuk mempraktikkan pembaharuan secara berterusan dan kearah kecemerlangan.

TABLE OF CONTENTS

CHAPTER	TITLE	PAGE
	DECLARATION	ii
	DEDICATION	iii
	ACKNOWLEDGEMENTS	iv
	ABSTRACT	v
	ABSTRAK	vi
	TABLE OF CONTENTS	vii
	LIST OF TABLES	xi
	LIST OF FIGURES	xiii
	LIST OF APPENDICES	xiv
1	**INTRODUCTION**	
	1.1 Background of the Research	1
	1.2 Statement of the Problem	3
	1.3 Objectives of the Study	4
	1.4 Scope of the Study	4
	1.5 Importance of the Study	5
	1.6 Layout of the Thesis	5
2	**LITERATURE REVIEW**	
	2.1 Introduction	7
	2.2 Small and Medium-Sized Company	7
	2.2.1. Definition of SMEs in Selected Economies	8
	2.2.2. Importance of SMEs	9
	2.2.3. Differences of Characteristics of the Large Companies and SMEs	10

	2.3	Manufacturing Performance Measurement	11
		2.3.1. Definition of Performance Measurement	12
		2.3.2. Performance Measurement Revolution	14
		2.3.3. Review on Previous Manufacturing Performance Measures	18
	2.4	Identified Manufacturing Performance Measures for SMEs	32
	2.5	Analytic Hierarchy Process (AHP) Methodology	37
	2.6	Summary	41
3	**RESEARCH METHODOLOGY**		
	3.1	Introduction	43
	3.2	Identifying A Set of Manufacturing Performance Measures for SMEs	43
	3.3	Survey Methodology	45
		3.3.1 Population and Sampling	45
		3.3.2 Developing the Questionnaire	46
		3.3.3 Data Collection Method	47
		3.3.4 Reliability and Validity of Instrument	49
		3.3.5 Normality Test	51
		3.3.6 Survey Administration	52
	3.4	Developing A Tool of Manufacturing Performance Measurement for SMEs	53
	3.5	Validating the Developed Tool by Case Study	53
	3.6	Summary	54
4	**SURVEY RESULTS AND ANALYSIS**		
	4.1	Introduction	55
	4.2	General Descriptive Statistics of Respondents	55
		4.2.1 Background of Respondents	55
		4.2.2 Manufacturing Performance (MP) Measures Implemented	60
	4.3	Reliability and Validity Test	63

4.3.1 Reliability Test 63
4.3.2 Validity Test 63
4.4 Normality Test 64
4.5 Results of Manufacturing Performance Measures for Small and Medium-sized Enterprises (SMEs) 66
4.5.1 Usage Level 66
4.5.2 Usefulness Level 68
4.5.3 Difference of Usage and Usefulness Level of Manufacturing Performance Measures 69
4.6 Summary 71

5 DEVELOPMENT OF MANUFACTURING PERFORMANCE MEASUREMENT TOOL FOR SMALL AND MEDIUM-SIZED ENTERPRISES
5.1 Introduction 73
5.2 Construct the Hierarchy of Manufacturing Performance Measurement for SMEs 75
5.3 Calculation of the Measures Relative Weight 77
5.4 Rating the Manufacturing Performance Measures for SMEs 80
5.5 Computing the Companies Score 82
5.6 Ranking the Companies Based on the Score 84
5.7 Development of Software-based Tool 85
5.7.1 Designing 86
5.7.2 Coding 93
5.7.3 Testing 94
5.8 Summary 98

6 VALIDATION OF THE MANUFACTURING PERFORMANCE MEASUREMENT TOOL FOR SMALL AND MEDIUM-SIZED ENTERPRISES
6.1 Introduction 100
6.2 Companies Background 100

6.2.1 Wonderful Wire & Cable Berhad 100
6.2.2 J.K. Wire Harness Sdn. Bhd. 102
6.3 Manufacturing Performance Measurement Practice in the Companies 103
6.3.1 Wonderful Wire & Cable Berhad 103
6.3.2 J.K. Wire Harness Sdn. Bhd. 104
6.4 Validation of the Manufacturing Performance Measurement Tool for SMEs 105
6.5 Summary 107

7 CONCLUSIONS AND RECOMMENDATIONS
7.1 Conclusions 108
7.2 Recommendations 110

REFERENCES 112
APPENDICES 122

LIST OF TABLES

TABLE NO.	TITLE	PAGE
2.1	Summaries of definitions for SMEs in selected economies	8
2.2	SMEs development and growth in selected economies	9
2.3	Characteristics of SMEs versus large companies	10
2.4	The gap of studies in manufacturing performance	30
2.5	Summary of manufacturing performance measures count	31
2.6	Dimensions of identified manufacturing performance measures	32
2.7	Descriptions of quality dimensions	33
2.8	Descriptions of delivery dimensions	34
2.9	Descriptions of cost dimensions	35
2.10	Descriptions of flexibility dimensions	36
2.11	Descriptions of time dimensions	37
2.12	Descriptions of labor dimensions	37
2.13	Scale of measurement in pair-wise comparisons	40
2.14	Random Consistency Index	41
3.1	Graphical methods versus numerical methods	52
4.1	The number of employees	56
4.2	Number of company product type	57
4.3	Number of years established in automotive industry	58
4.4	Number of company certification	58
4.5	Number of company award	59
4.6	Number of years implemented	59
4.7	Factors of MP used by the companies	60
4.8	Factors of MP ranked by the companies	61

4.9	Factors of MP focused more by the companies	61
4.10	The appropriateness of the MP measures by the companies	62
4.11	Cronbach's Alpha for the MP Factors	63
4.12	Results of the normality test	65
4.13	Mean usage level of the measures	67
4.14	Mean usefulness level of the measures	68
4.15	Paired sample statistics for usage and usefulness level	70
5.1	The pair-wise comparison of the factors	77
5.2	Final results of pair-wise comparison factors and dimensions	80
5.3	Rating guideline	81
5.4	Result of the measures rating	81
5.5	The individual factor scores of companies	83
5.6	The overall scores of companies	84
5.7	The ranking overall score of companies	85
5.8	The ranking individual factor score of companies	85

LIST OF FIGURES

FIGURE NO.	TITLE	PAGE
2.1	Framework for PMS measures	20
2.2	Diagram illustrating framework structure	23
2.3	Conceptual framework	25
2.4	Structural equation model operationalizing framework	27
2.5	The hierarchical structure of a decision problem	39
3.1	The outline of research activities	44
3.2	Comparisons of major survey methods	49
4.1	Respondents position in the company	57
5.1	The stages of manufacturing performance measurement tool for SMEs	74
5.2	The hierarchy of manufacturing performance measurement for SMEs	76
5.3	Flow chart of user input design	87
5.4	Flow chart of admin input process	88
5.5	Flow chart of process design	89
5.6	Database structure	92
5.7	The main page	94
5.8	User register page	95
5.9	Input value of measures page	95
5.10	Input pair-wise comparison page	96
5.11	Relative weights of the measures	96
5.12	The company score	97
5.13	The scores of companies	97
5.14	The rank of companies	98

LIST OF APPENDICES

APPENDIX	TITLE	PAGE
A	**Survey Questionnaire and Letters**	
A-1	List of experts	122
A-2	Sample letter of experts	123
A-3	Questionnaire	124
A-4	Sample letter for survey	128
A-5	Sample follow-up letter for survey	129
B	**Case Study and Letters**	
B-1	Sample letter for case study	130
B-2	Case study questionnaire	131
C	**Statistical of Survey Results**	
C-1	Background of respondents	136
C-2	Number of the companies product types	137
C-3	Number of the companies certified	138
C-4	Number of the companies awarded	139
C-5	The manufacturing performance factors implemented	140
C-6	The manufacturing performance factors ranked	141
C-7	The manufacturing performance factors focused	143
C-8	The appropriateness of manufacturing performance measures	144
C-9	Reliability test	145
C-10	Normality test	147
C-11	Results of manufacturing performance measures for SMEs	153

C-12	Difference of usage and usefulness level on manufacturing performance measures for SMEs	156
D	**Software Guidelines**	
D-1	User guideline	163
D-2	Admin guideline	167
E	**Publications**	173

CHAPTER 1

INTRODUCTION

1.1 Background of the Research

Small and medium-sized enterprises (SMEs) have been heralded as a vital group in gaining and maintaining national competitive advantage worldwide especially in the development of a knowledge economy by providing a route for the creation of employment and the generation of wealth in the twenty first century.

The globalization of markets, growing inter-diffusion of economies, and increased inter-dependence of economic agents are reshaping national and international competitive environment and economic performance (Ghobadian and Gallear, 1996). Competitive pressures in global manufacturing are forcing manufacturing organizations to re-examine and modify their competitive strategies. Small and medium sized enterprises (SMEs) are not exempted from these pressures. They have to pay more attention to the changes in manufacturing performance system including the measures used. They need to have a set of manufacturing performance measure to gauge their level of achievement.

Hudson (2001) suggested that there are numerous barriers to strategic performance measurement system implementation in SMEs. The failure of the implementation was attributed primarily to the development process being: too resource intensive and too strategically oriented. This concurs with the limited

resources and the more dynamic, emergent, strategy styles found in SMEs. These issues are acutely problematic because developing a strategic performance measurement system is necessarily long term and it explicitly requires the resulting measures to be strategically focused. The significant differences in the structure and philosophy of SMEs indicate that there is a need to assess the relevance of the strategic performance measurement.

The last twenty years has witnessed a revolution in performance measurement (Neely and Bourne, 2000). This revolution has been driven by changes in the business environment, which has led to the recognition that conventional measures do not present a complete picture of organizational performance, hence the development of critical measures (Stone and Banks, 1997).

According to Ghalayini and Noble (1996), the literature concerning performance measurement has evolved through two phases. The first phase started in the late 1880s which is characterized by its cost accounting orientation. This orientation aimed at aiding managers in evaluating the relevant costs of operating their firms. It was later modified in an attempt to incorporate some financial measures such as profit and return on investment. However, even with somewhat of a financial focus, this approach received considerable criticisms. Critics argued against focusing solely on financial measures, when measuring performance tends to encourage short-term thinking (Kaplan, 1983). This argument was further reinforced on the grounds that traditional financially-based performance measurement systems failed to measure and integrate all the factors critical to business success (Kaplan, 1984).

The mid-1980's was a turning point in the performance measurement literature, as it marked the beginning of the second phase. This phase was associated with the growth of global business activities and the changes brought about by such growth. Johnson and Kaplan (1987) underscored the need for better integrated performance measurement, as they criticized the traditional performance measures, due to their focus on the minimization of variance rather than on continuous improvement. The authors contended that traditional financial measurement systems are, for the most part, irrelevant because they ignore customers and their needs.

Based on similar grounds, McNair and Mosconi (1987) called for the development of better integrated performance measurement systems. They underscored the need for the alignment of financial and non-financial measures in order to be in accordance with business strategy.

Current studies have showed that quality, cost, delivery and flexibility are the commonly cited performance measures relating to competitive priorities (White, 1996; Small, 1999; Medori and Steeple, 2000; Toni and Tonchia, 2001; Yurdakul, 2002; Christiansen et al., 2003; Fynes et al., 2005; Neely et al., 2005; Diaz et al., 2005; Tarigan, 2005; Cua et al., 2006; Meybodi, 2006; Liao and Qiang Tu, 2008; Ahuja and Khamba, 2008). Time and labor are also considered to be a critical measure of performance measurement (Small, 1999; Mapes et al., 2000; Hudson et al., 2001; Toni and Tonchia, 2001; Najmi and Kehoe, 2001; Yurdakul, 2002; Abdel-Maksoud, 2004; Neely et al., 2005; Gosselin, 2005; Meybodi, 2006; Gomes et al., 2007; Ahuja and Khamba, 2008).

Other measures are also used to measure manufacturing performance such as customer satisfaction, finance, innovation and efficiency (Mapes et al., 2000; Hudson et al., 2001; Najmi and Kehoe, 2001; Abdel-Maksoud, 2004; Narasimhan et al., 2005; Gosselin, 2005; Gomes et al., 2007; Liao and Qiang Tu, 2008).

1.2 Statement of the Problem

Manufacturing performance measures are needed for manufacturing organizations to achieve their goals and objectives. Companies need to determine the performance measures to evaluate, control, and improve production process by measuring manufacturing performance.

Although manufacturing performance measurement has been in existence for many years, it seems that there is no consensus on the collective set of measures used by companies. Most researchers and authors defined the manufacturing performance measures in terms of quality, cost, delivery and flexibility. There is also a bulk of

researches that used other measures such as time, human resource, financial, customer satisfaction, innovation, and efficiency. Very few researches have developed to the manufacturing performance measurement for SMEs.

It is believed that there is a need for assessing manufacturing performance for SMEs, which suitable and useful to their characteristics. The focus of this research is to develop a tool to assess manufacturing performance for SMEs, which hopefully will help them to keep track of their performance.

1.3 Objectives of the Study

The objectives of this study:

a. To formulate a set of manufacturing performance measures for SMEs.
b. To develop a tool to assess manufacturing performance for SMEs.

1.4 Scopes of the Study

The scopes of this study:

a. The focus of this research is the Small and Medium-sized Enterprises (SMEs), limited to Malaysian automotive component part manufacturers.
b. The manufacturing performance measures were used in this research derived from the literature review, focused on quality, cost, delivery, time, flexibility, and labor.
c. The manufacturing performance measurement tool was developed by using Analytic Hierarchy Process (AHP) methodology.
d. A software-based tool was developed by using PHP and MySQL.

1.5 Importance of the Study

The research on the development of a tool to assess manufacturing performance for SMEs is very important and useful, particularly in a competing environment. A set of manufacturing performance measures for SMEs is expected to be suitable to their characteristics and improve their competitiveness. The measures are then used in developing a tool to assess manufacturing performance for SMEs.

The manufacturing performance measurement tool for SMEs enables and assists in their efforts to continually improve their manufacturing performance so as to become more efficient and effective. The tool can also be used to compare the manufacturing performance of different companies, plants, and departments. Besides that, the tool can be used for supplier selection and evaluation to achieve a certain level of manufacturing performance to ensure the suppliers have good manufacturing performance and good support to the manufacturing. In this case, the company can select suitable and appropriate suppliers that meet their criteria.

1.6 Layout of the Thesis

This report consists of seven chapters. The first chapter provides an introduction to the research. It describes the background of the research, statement of the problem, objectives, scopes, and importance of the study. Chapter 2 presents a critical review of Small and Medium-sized Enterprises (SMEs) including the definition of SMEs in selected economies, importance of SMEs, and differences of SMEs and large companies; manufacturing performance measurement including definition of performance measurement, manufacturing performance revolution, and a review on previous manufacturing performance measures; identified manufacturing performance measures for SMEs; and Analytic Hierarchy Process (AHP) methodology.

The research methodology employed in conducting this study is described in Chapter 3. The research begins with identifying a set of manufacturing performance

measures for SMEs derived from the literature. A survey was then conducted to match the measures with industry practices. A questionnaire was designed to investigate the measures being practiced and those believed to be useful in SMEs. The next step is developing a tool to assess manufacturing performance for SMEs. The tool was validated by conducting case study to selected SMEs.

Chapter 4 presents the survey results and analysis. The survey has investigated the manufacturing performance measures being practiced and the level of usefulness in SMEs. Data from the survey was analyzed and a set of manufacturing performance measures for SMEs was proposed which hopefully are suitable to their characteristics.

The development of manufacturing performance measurement tool for SMEs is described in Chapter 5. The tool was developed using Analytic Hierarchy Process (AHP) methodology. A software-based tool was subsequently developed for automating the process. It is a web based-software developed using PHP and MySQL. Chapter 6 presents the validation of manufacturing performance measurement tool for SMEs. The developed tool was validated by conducting two case studies in Malaysian automotive SMEs.

Finally, the discussion of the previous chapters is provided in Chapter 7. To cover all the activities in this study, some conclusions are presented and some recommendations are proposed for further improvement.